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FIGURES 135-138.—The development of the feathers of the young Robin.
(Observed in the garden at Odstock, Hanwell, 1903.)

ETON NATURE-STUDY

AND

OBSERVATIONAL LESSONS

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BY

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WITH A FOREWORD BY

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Headmaster of Eton

PART II

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NOTE

In bringing out Part II of "Eton Nature-Study" and thereby completing our work, we would like to take the opportunity of thanking not only the Press for the kindly notices that it has accorded to Part I, but also those private correspondents who have given us the benefit of their encouragement and friendly criticism. Space forbids us to enter into any general discussion of the points raised, but there is one to which we will very briefly refer.

It has been said that however desirable Nature-Study may be for young children, it is out of place at a public school, and that didactic methods of teaching are alone possible for boys of thirteen and fourteen years old where so few hours a week are devoted to the acquisition of natural knowledge. If good results in writing answers to questions set by external examiners are alone aimed at, this may be quite true; but we are not alone in thinking that often very little real education may result from such methods. Furthermore we are not prepared to deny that for a certain number of boys, teaching on the lines that we have suggested cannot be adopted with any great effect, but we believe that such boys belong to that class, which most teachers will admit to exist, to whom any kind of intellectual occupation is repugnant. Again, while it is certain that Nature-Study is best begun in early years, we cannot forget how often it is asserted that unless the public schools lead the way, preparatory schools cannot be expected to make any alterations in their methods or in their time tables. Partly for this reason, and partly because our experience tells us that the percentage of boys above alluded to, is

happily growing smaller, we determined to embody in a book some of the methods which we have adopted in carrying on our own work.

We hope that the book may result in more time being given in modern educational curricula to matters that interest the great majority of English speaking boys and girls, and that it may help them to acquire that love for Nature and out-door life which is characteristic of their race.

M. D. H.
W. M. W.

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OBSERVATIONAL LESSON XVII

Part I—A Seedling (*continued, 2nd Investigation*)

Preparations for Work

Once more the pots that contain dwarf bean plants which have germinated in sawdust will be needed (see Part I, pages 133 and 137). For purposes of studying the plants in the future, it will be advisable to grow a second series of specimens in pots containing soil.

Directions to the Pupil

(1) Take out your seedling and shake off as much of the sawdust as possible from it.

Describe :—	Make :—	Leave :—
Any changes that have taken place	A sketch as usual	A space for a finished drawing

Suggestions for Further Work in School

During the week, the seedling should be watched and the process by which the first bud frees itself from the seed-coats and makes its way into the air should be seen, and if time allows, sketched. Other seeds may with advantage be germinated and their manner of growth compared with that of the dwarf bean.

Part II—The Sun (*continued*)

Should an opportunity arise, make a further record as to the position of the sun. Mark the window and floor accordingly. (See Part I, pages 20 and 22.)

Note :—This observation should be repeated at short intervals whenever the sun can be seen.

Part III—A Potato Tuber

Preparations for Work

Potato tubers of moderate size should be obtained; some of these which have begun to sprout will be planted during the lesson in boxes filled with earth and having one side of glass. Arrangements should be made for covering the glass so that the light is excluded when the potato is not being examined. As an alternative, especially when the observations are not to be continued during the summer, the potato may be suspended in a glass or jar over water. A strip of solder will serve to support the tuber, if twisted round it and the ends bent so as to hook over the sides of the jar. There should be one specimen at least for every two pupils.

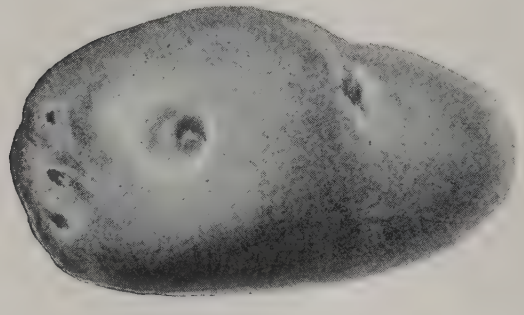

Figure 139.—A Potato tuber.

Directions to the Pupil

(2) Treat the potato as you have your specimens in previous lessons. Put down headings in your note-book with regard to its size, shape and colour. Make sketches as usual and add your observations upon the external appearance of the specimens.

(3) Next, consider the thickness of the skin, the colour of the flesh, and any other points that you may determine by cutting into the potato.

(4) Describe and sketch a second tuber which has just begun to sprout, afterwards set it in a box full of earth which has a window in the side. Put the tuber close to the glass where you can see the sprouts.

(5) Suspend a tuber over a jar containing water by means of a strip of solder twisted round it.

Note:—Potatoes grow slowly, and further investigations will be made in alternate lessons: this arrangement need not, however, preclude additional observations from being made at shorter intervals.

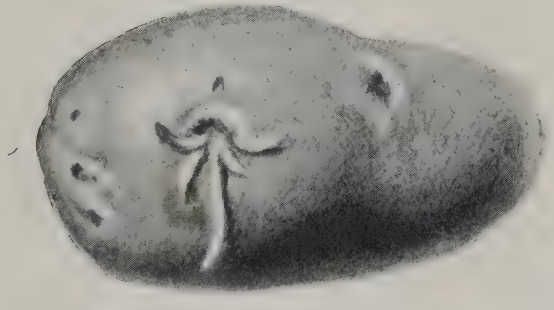

FIGURE 140.—The developing "eye" of a Potato tuber.

CHAPTER XVIII

THE STOREHOUSES OF PLANTS—NEW PLANTS FROM OLD PIECES

The Storehouses of Plants

It is quite evident from the fact that we can grow seedlings in sawdust or sand that seeds must have within them, material for building up the bodies of young plants. Even if this were not easily determined, seeing that we eat beans and wheaten bread, they must contain supplies of food, and the same is true of many tubers and roots. We take advantage therefore of the stores of food, which plants lay by for the immediate needs of their offspring or for their own future use. It will not be an uninteresting pursuit to continue in this connection the work suggested at the beginning of Chapter X, for many plants' storehouses are situated under the soil. One plant may produce a number of others, or merely form a single new tuber or bulb for use during the following year, as in the case of the bulbous buttercup and some of our native orchids. At the same time it must not be forgotten that there are other storehouses above ground; for instance the swollen buds of the lily, which drop to the earth and give rise to a new plant, grow from the bases of the leaves. Visits also to greenhouses, in which foreign plants are grown, will show that tubers and other swollen structures may be developed on stems. The potato, even, sometimes forms tubers at the bases of

the leaves, and when it is grafted upon a tomato it has no option but to produce them above ground.

It is easily seen that many of the storehouses which become separated from the old plant, commonly take the place of seeds. The potato tuber is a case in point, and the branches of creeping underground stems will each form a new plant when the old stem dies and rots away. The farmer and gardener know to their cost that any little bit of the stem of twitch grass or of convolvulus can live a separate existence. It would be surprising if we did not make use of bulbs and tubers instead of seeds, in fact, we go even further and induce parts of plants which do not ordinarily part company with their parents to send out roots or shoots, or both. The great point is that the part of a plant which is to lead a separate existence must have, in addition to the necessary powers of growth, sufficient food stored away in it to nourish the new roots and shoots until they can make a living for themselves. It will be found that cuttings need not always be made from stems, though these are by far the most familiar kind.

Photograph by Wilfred Mark Webb.

FIGURE 141.—A "Geranium" cutting.

New Plants from old Pieces

A willow twig broken from the tree and merely stuck into the ground will grow. Little difficulty, also, will be met with in "striking" the shoots of roses or currants after their leaves have fallen. To grow plants from leafy cuttings is, however, not always so easy. Success depends upon the powers of the foliage to retain moisture, and upon the devices of the horticulturist to prevent the leaves from flagging until roots are formed to supply them with water. Cuttings with fleshy leaves grow well, as do those with a substantial stem and hairy foliage, like the common "geranium" (see figure 141). As active growth means the need for plenty of air, and cuttings to be grown in pots should be set near the porous sides of these and in light soil* so that the new tissues may breathe properly. Some thick leaves, should they be broken off a plant and allowed to lie on the ground, will send up of their own accord quite a forest of young plants (see figure 144). Similarly if a scale be detached from one of the bulbs of the lily, it may produce

Figure 142.—Young Lily bulbs growing from an old scale.

* Some plants, the roots of which work in association with threads of fungi, need to be "struck" in peaty soil, which contains their allies.

several new plants (see figure 142). It is easy to take these scales and, after setting them to half their depth in light soil, to follow out the process. In propagating begonias, gardeners break the ribs of the leaves which they detach from the plant and peg them down to the ground; buds and leaves and roots are formed as may be seen in Figure 143. Other leaves, such as those of gloxinia, can be induced

Photograph by Wilfred Mark Webb.

FIGURE 143.—A Begonia leaf producing new plants.

to do the same if treated in a similar way; and if the stalks of the leaves of peperomia and saintpaulia* are stuck into pots of soil, they will root and send out buds.

Successful experiments can also be made with the leaves of various

* See Appendix.

stone-crops. We have seen a leaf of celery—partly separated from the parent plant—which has sent out roots, and it is possible that numbers of others hitherto untried might grow independently.

Roots do not generally produce buds, but sea-kale is commonly grown from root-cuttings. There is a large field for experimenting

Photograph by Wilfred Mark Webb.

FIGURE 144.—Young Bryophyllum plants growing from a detached leaf.

as to the powers of plants which have been briefly outlined. If a greenhouse is available it will be a help, but little difficulty should be met with in protecting the specimens by covering them with glass jars, so that they do not dry up unduly, before the new roots can secure moisture from the soil.

OBSERVATIONAL LESSON XVIII

Part I—A Seedling (*continued, 3rd Investigation*)

Preparations for Work

Distribute the dwarf bean seedlings which have been grown in soil.

Directions to the Pupil

(1) Note down :—	Make :—	Leave :—
The number of leaves on your plant and mark one of them so that you can measure its increase in size during the next lesson	A sketch of the seedling drawn to scale	A space for a finished drawing

Part II—Frog's Eggs

Preparations for Work

A small piece of frog's spawn should be placed in a glass and given to each pupil. The eggs to be examined should be as young as possible (those which are light coloured must be chosen). Pocket lenses will be useful.

Note :—If the frogs have not yet spawned, prepare for the alternative part of the lesson.

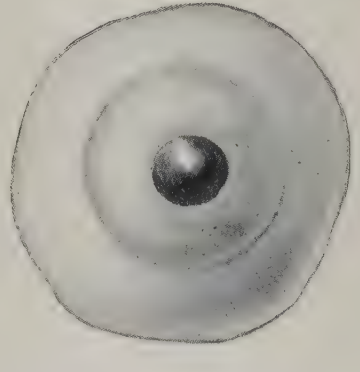

Figure 145.—A Frog's egg.

Directions to the Pupil

(2) Observe and describe an egg and its surrounding jelly—of what use is the latter?

(3) Look at an egg with a pocket lens, make a sketch of it and give a few words of description.

Alternative Subject for Part II—A Corm

Preparations for Work

If frog's spawn cannot be obtained, distribute a number of crocus plants in flower which have been carefully dug up and from the roots of which the soil has been washed away.

Directions to the Pupil

(2a) Make a sketch showing all the parts of the crocus plant that you can see, and label them.

(3a) Answer the following questions :—

i. From whence do the roots spring ?

ii. Is the corm of a crocus more like the hyacinth bulb or the potato tuber ?

iii. Where is the young pod which will contain the seeds of the crocus ?—Show this by means of a sketch of a perfect flower.

Photograph by Wilfred Mark Webb.

Figure 146.—A Crocus.

Part III—A Hen's Egg

Preparations for Work

New laid eggs will be required, one for each pupil.

Directions to the Pupil

(4) Carefully crack a little piece of the hen's egg on the upper surface as it lies on the table, and pick off the shell. Describe what lies beneath.

(5) Remove the skins of the egg. Say how many there are, and sketch what you see below.

CHAPTER XIX

THE HATCHING OF TROUT EGGS—THE TOAD—A FRESH-WATER AQUARIUM—THE NESTING OF THE STICKLEBACK

The Hatching of Trout Eggs

The culture of fish has for some years past attracted considerable notice, and in many places large fish-hatcheries have been built for the rearing of immense numbers of the young of the salmon, trout, and other members of the same family. It is easy therefore to obtain fertile eggs of the trout, and in order to hatch them, little is necessary beyond a supply of clean running water. To rear a large number of fry, a natural or artificial stream is necessary.

To watch the gradual growth of an active little fish from the egg, will be found highly diverting, and little trouble need be spent in looking after the eggs until the fish are quite formed.

A convenient form of hatching apparatus is supplied by the Solway Fishery Company.*

Otherwise a box or series of boxes (a convenient size being twenty inches long, four and a half inches deep, and six inches wide) should be arranged one above the other, so that the water can fall by means of lips over the side of one box into the next below it. Fill the boxes with boiled gravel to the depth of about half an inch, and allow water to the depth of two inches to flow over the eggs. A

* See Appendix.

small hatchery can be placed in a sink. Do not crowd the eggs together; in fact, they should not touch one another. As soon as an egg is dead, and some are sure to die, it should be removed. A dead egg is at once recognised by its dull pale-white colour. As soon as two black dots appear (see figure 149), the eyes of the future fish, the chief danger of the egg dying is past. The temperature should not be above 50° Fahrenheit (40° to 50° being the best), the fish which takes the longest time to hatch out being always the strongest. The exact moment of hatching should be carefully looked for (see figure 150), and the gradual absorption of the food-bag should be noted from day to day. After this has disappeared the young fish should be taken out of the boxes, since water which is sufficient for a given number of eggs will not be enough for the same number of young fish when they come out. They will want feeding, and for this purpose the fresh roe of any small fish will do, such as that of a sole or whiting, which can easily be got from a fishmonger.* The great thing to avoid is giving the fish more than they can eat. Any remnant of uneaten food should be removed. The

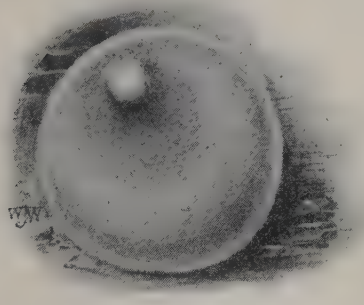

FIGURE 147.—A Trout egg.

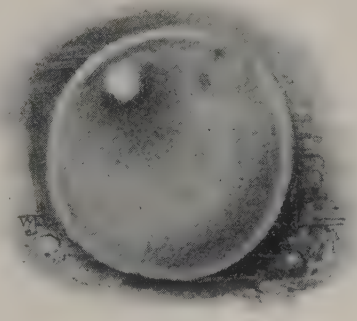

FIGURE 148.—A Trout egg faintly "eyed."

FIGURE 149.—A Trout egg fully "eyed."

* Other foods have of late years superseded fish roe. A list of these, of eggs, and apparatus, may be obtained from The Manager, Earl Denbigh Fisheries, Holywell, North Wales.

troutlets (see figure 152) will also feed readily on small red worms, flies, and such like.

Trout are certainly the best fish to begin with, but after the student has gained experience, others such as the salmon, sea-trout, and charr may be reared.

FIGURE 150.—A Trout egg hatching.

THE TOAD

The question of fish-culture, and the hatching of the eggs of fish, suggests the study of other animals that lay their eggs in water—the frogs, and toads, and the newts. There are probably very few, if any, who would not recognise a mass of frog's spawn, yet how many know the eggs of the common toad? Late in March and early in April is the time when toads leave their usual homes and seek pools and marshes in order to lay their eggs. They may often be seen in large numbers near the banks of ponds, and the melodious note of the male is easily to be distinguished from the harsh croak of the frog.

FIGURE 151.—A newly hatched Trout or "Allevin" showing the yolk sac.

There are no animals that will repay attention and care more than toads, especially the little natterjack, common in sandy districts. Unlike the frog,

the toad is easy to keep in vivaria, and will soon become tame enough to take a living insect from the hand. It is, however, in the garden that the toad is seen to best advantage, and it is strange that the great good this animal does to cultivation is not more generally recognised. Few animals in the way of slugs, caterpillars, and beetles, seem to come amiss to the toad. We should

FIGURE 152.—A young Trout in the "fry" stage after the yolk sac has been absorbed.

hear far less of the depredations of garden pests if toads were treated as welcome guests in our gardens. Probably the ugliness of the creature, and its reputed power of spitting venom, and suchlike nonsense, account for the popular dislike in which the animal is held. We should recommend therefore the nature student to see that his garden has a plentiful supply of toads, and at the same time to watch the habits of these animals in his vivarium.

The method of catching his prey, employed by the toad, the removal of his skin and its ultimate fate, the measurement of his

powers of sight and hearing, and last but not least his behaviour with wasps and other harmful insects, will furnish plenty of opportunities for careful observation.

Newts

The tailed amphibia or newts are always popular inmates of aquaria. An excellent cage for these creatures is made by taking an ordinary bell jar and fixing to it an arrangement such as is shown in Figure 153.

There are three different species of newts found in Britain, and the student should try and find specimens of all. The methods of egg-laying, and the different kinds of food of these animals, are still matters requiring observation.

A Fresh-Water Aquarium

Directions were given in Part I, Chapter III, as to the keeping of a marine aquarium, and the difficulties attendant on its successful management were pointed out. Animals and plants, however, that live in fresh water are much more easily dealt with.

It will probably be found, however, that hard water (namely that containing salts of lime) had better be avoided, except for large aquaria in which fish are kept in a constant supply of running water. For still aquaria, rain water will give the best results in the case of molluscs and insect larvae and pond mussels, and especially the delicate hydras and protozoa. The latter indeed should be kept in small glass vessels rather than in large aquaria, when they can be better looked after.*

* See Appendix, for hints on the cultivation of Protozoa.

An equable temperature must be maintained if possible. Washed sand and gravel should cover the bottom, and two or three large flints set up against one another will form a hiding-place. Direct sunlight should be screened from at least half of the aquarium.

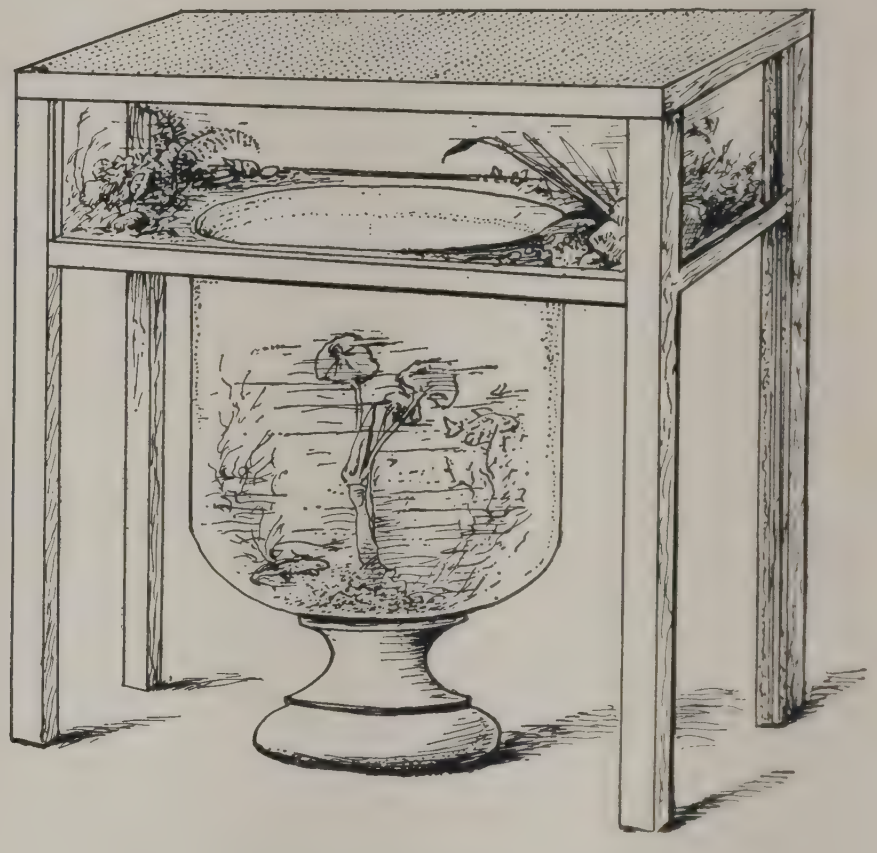

FIGURE. 153—A Terrarium with accommodation for amphibious animals.

Several kinds of water plants will serve as aërators of the water, crow-foot, goose-weed, and duck-weed being hardy and easily grown. In aquaria supplied with running water the vallisneria plant will flourish, but not otherwise. There are many excellent handbooks as to the management of aquaria, and their most profitable denizens,

we will therefore do no more than suggest a few points on which observation is much needed.

(1) The attention of naturalists might be directed towards the pupae of many beetles, especially that of the "whirligig" beetle which, according to Professor Miall, has very rarely been seen. Furthermore, the various contrivances of aquatic insects for locomotion, egg-laying, and breathing, the defences of resting pupae, and so on, are all worthy of attention. For hints as to what may be done in this branch of the subject, no better work can be cited than "Aquatic Insects" by Professor L. C. Miall. (Macmillan.)

(2) The habits of many water snails form a subject about which little is really known. If the student keeps several paludinae (fresh-water whelks) in an aquarium, and watch them from time to time, he will discover that the movements of these creatures are not haphazard but according, apparently, to certain regular instincts. It is not our purpose to do more than suggest lines of observation, but we may say, from personal experience, that this particular animal will certainly repay observation.

(3) The breeding habits of leeches have been but very little studied. The horse-leech and one or two other common forms occur abundantly in most places.

(4) The movements of the common pond mussel have been very insufficiently observed, especially the part played by the "foot." Shortly after dusk will be found to be the best time for watching these molluscs. The attachment of the young to other animals is particularly interesting.

These examples have been taken at random, but the student who takes up the study of any particular group of animals will soon realise that there is plenty for him to find out, not to mention the re-discovering of facts already known.

The Nesting of the Stickleback

It is by no means difficult to prevail upon sticklebacks to build their nests and lay their eggs in captivity. An aquarium should be

Figure 154.—The nest of the seven-spined Stickleback.

prepared for the purpose as already directed (on page 15) some little time beforehand, and should be well supplied with weed. Into this, at the approach of the breeding season (about the middle of April),

when the male fish has assumed his characteristic and brilliant colours and the female is filled with roe, a pair should be introduced.

It will be perhaps advisable to restrict the experiment to a single couple,* as the male fish are very pugnacious. This is the outcome of the care and attention which they lavish upon the nest and eggs. When the young leave their home, which they do when the yolk sac is absorbed, the parents should be removed from the aquarium or they will probably devour their tiny offspring. The development of the young stickleback should be compared with that of the trout already studied.

* This is the advice of Mr J. W. Gooch of Windsor, who has been most successful in obtaining the nests of sticklebacks.

OBSERVATIONAL LESSON XIX

Part I—A Seedling (*continued, 4th Investigation*)

Preparations for Work

Put ready the pots containing the dwarf bean seedlings.

Directions to the Pupil

(1) Carefully examine the leaf which you marked in the 1st lesson. Make diagrams of it, showing its size to-day and a week ago. If time allow, make an outline drawing of the whole plant, or if not, draw a line to indicate its height, making a note of the increase during the week.

Figure 155.—A Potato tuber showing "sprouts."

Part II—A Tuber (*continued, 2nd Investigation*)

Preparations for Work

The growing potatoes will be needed.

Directions to the Pupil

(2) Record by means of notes and sketches any changes that have taken place or signs of growth that have manifested themselves.

Part III—A Developing Tadpole

Preparations for Work

The same will be required as for Part II of the last lesson. The frog's spawn will be a week older.

Note:—If no spawn was obtained for the last lesson it should be studied at this point. If it still cannot be procure l, substitute the alternative subject.

Figure 156.—A Frog's egg, 8 days old.

Figure 157.—A Frog's egg, 12 days old.

Directions to the Pupil

(3) Examine and sketch the frog's spawn as before and describe shortly what has happened; sketch the egg.

Alternative Subject for Part III—A Pumpkin Seedling

Preparations for Work

It was suggested in Part I, page 134, that the seed of the pumpkin should be compared with that of the bean. Should frog's spawn again be lacking, a series of seedlings of the pumpkin might be examined and drawn.

Directions to the Pupil

(3a) Make a sketch of a germinating pumpkin seed in the same stage as the bean seen in figure 127, Part I, page 134.

Take another, corresponding to figure 132, Part I, page 139.

Take a third, in which the little plant is withdrawing itself from the seed-coat. Can you find among your drawings of the bean one which corresponds to this stage of the pumpkin? What do you think is the great difference between the two seeds.

Part IV—A Developing Chick

Preparations for Work

Hens' eggs which have been incubated for twenty-four hours should be ready.

Directions to the Pupil

(4) Remove the outer coverings of half of the hen's egg, and describe and draw what you see.

(5) What do you consider to be one most important difference in the development of the eggs of frog and hen.

Suggestions for Further Work in School

Eggs that have been incubated for two days might be examined and the developing chick seen. The beating of the heart can be made out, and blood-vessels will have made their appearance on the surface of the yolk.

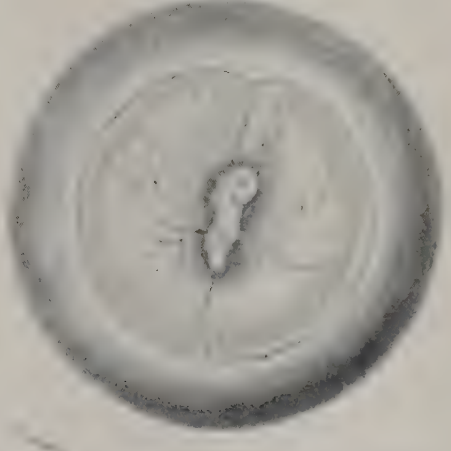

Figure 158.—A developing Chick, two days old.

CHAPTER XX

THE COVERINGS OF YOUNG BIRDS

The consideration of birds' eggs has long been popular, though now the tendency is rather for nature students to preserve pictures of nests and their contents than to "take" them to form a collection. A deal of discussion has taken place with regard to the meanings of the colours of eggs, but quite as much interest surrounds the appearance of newly hatched birds and the rapid changes that take place in it. A great amount of new work might be done in the direction of showing how far and in what cases the coloration of young birds is protective. There are of course familiar instances of young birds which do not remain in the nest or lie in an apology for one, that are practically invisible unless they move, but little observation has been brought to bear upon nestlings.

The black down which is to be seen on young robins (figures 135-138), forming the frontispiece of Part II) is most striking, and the feathers, mottled with yellowish markings, which replace it, differ greatly from those of the adult bird. There are of course many possibilities of the colouring of nestlings being similar to that of their remote ancestors as are the spots on young lions or tapirs and the stripes on the young of the wild boar.

We may distinguish birds which are hatched completely covered with down and able to run about to feed themselves as soon as

they leave the egg,* from those which come out in a more or less naked condition. Almost any young birds will afford opportunities for a series of interesting observations as to the development of feathers and the way in which these replace the down. Perhaps, however, the more helpless nestlings are the best for the purpose. In the third drawing of the young robins already alluded to, the row of growing feathers round the neck is particularly well seen; each of them is pushing out the plume of down which it is replacing. The fourth drawing represents the stage in which but little down is left.

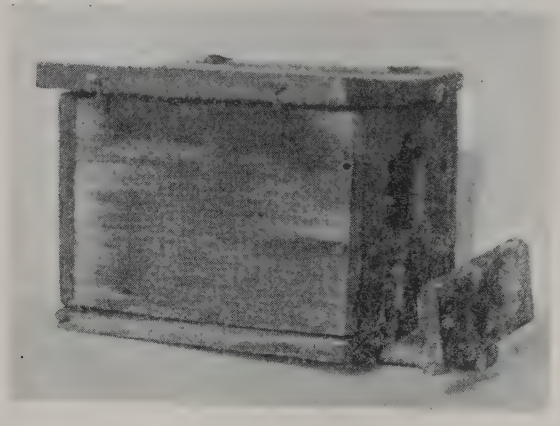

FIGURE 159.—A closed-in Nesting Box.

It is often possible to induce wild birds to nest in boxes provided for the purpose. In fact, the young robins which we have figured were hatched within a few yards of the table on which these words are being written. They were the second brood, and the open box in which their nest was built is shown in figure 160. The previous nestlings were reared in a closed box at the back of the house (see figure 159) which was placed on the bare wall upwards of seventeen feet from the ground. The weather was at that time much colder than when the second clutch of eggs was

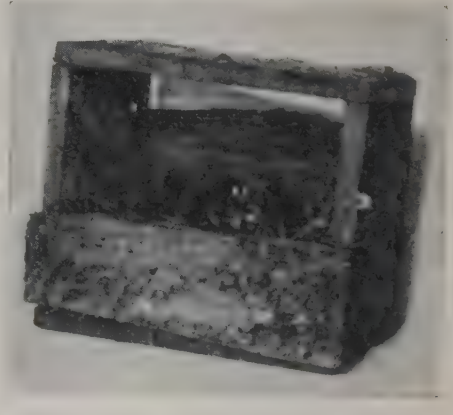

FIGURE 160.—A Nesting Box with the side open.

* The young of the mound-building birds are able to fly almost as soon as these are hatched.

laid, a fact which may have influenced the choice of the parent birds.

Both boxes were roughly made from the brown wooden cases in which tinned pine-apple is sent to this country. White wood needs to be painted, as until it becomes weathered it does not look well. In the second instance four eggs hatched and three nestlings survived, and although the hen bird, which for some reason unknown had become quite bald, died some days before her young flew, the cock successfully did double duty and brought off the brood.

Where robins will not build, it is easy to persuade sparrows to take possession of a nesting box, and the nestlings, though not quite so interesting as young robins, nevertheless show the developing feathers particularly well.

Squab pigeons or young canaries will serve as well if wild birds are not available. Should an attempt be made to rear canaries, it is advisable to bear in mind some of the details which have been noticed with regard to the nests of similar birds in nature. Most of the breeding cages to be bought ready made, are supplied with small wooden boxes a few inches square, in which it is intended that the nest should be made. Some books advise the use of the halves of cocoanut shells lined with saddler's felt. In this connection it is interesting to compare them with the accommodation that is afforded in the nest of the common sparrow, a bird so similar in size to the canary that, if report be true, painted examples are sometimes sold for the latter. The regulation nest box is far too small, its hard sides are so near to the nestlings that as they grow there is not sufficient soft material to give and make room for them; little air can reach either the eggs or the young birds when the hen bird is sitting upon them. The result is that but one or two young canaries are reared at a time. Instead of the

nest box, a small cage, about six inches by five inches, should be used, such as can be obtained at a bird fancier's; the door, which is at one end, should be taken off, a number of good sized holes should be bored in the floor, and a piece of carpet laid over it. After this the whole structure should be covered with

Photograph by Wilfred Mark Webb.

FIGURE 161.—A Series of Chickens of the same brood at different ages showing the replacement of the downy covering by feathers. The fifth primary feather of the right wing is shown at the side of each specimen. (From the specimens in the British Museum, Natural History, presented by Mr W. B. Tegetmeier.

brown paper, except on the bottom and at the open end, which is to hang against the outside of the breeding cage so that the birds

enter it through a hole cut for the purpose. To admit light to the nesting cage three slits must be cut in the brown paper so that a flap may be raised or lowered at will. Within, a rough nest can be fashioned with hay, and a supply of hair and moss and soft feathers given to the birds so that they may complete the structure. With such a nest as this it is possible to rear as many as six young birds at a time. In some books it is recommended that the yolk of the hard-boiled eggs, which is given to canaries in the breeding season to supply them with animal food for themselves and more particularly for their young, should be chopped up and mixed with crumbled biscuits. To do this is troublesome, and it would appear to defeat the end in view; instead, the hard-boiled eggs should be cut in two and a half wedged into a little pan to which the birds have access. They then may help themselves to the yolk and, if they wish, to some of the white also. If careful observations are to be made upon nestling canaries, it may be advisable to build a special nest cage of which the sides or roof can be temporarily removed and the contents examined.

To show the other type of young birds, chickens may be chosen (see figure 161) or pheasants' eggs placed under an ordinary hen. It is well worth while to see the accurate way in which the young pheasant chick breaks through the shell by making a circle of pecks. The result is that part of the shell falls away like the lid from a box. Such birds have a scale on the beak which helps in the process. Are all birds likewise endowed?

OBSERVATIONAL LESSON XX

Part I

A Developing Tadpole (*continued, 2nd Investigation*)

Preparations for Work

The frog's spawn will now be about fourteen days old.

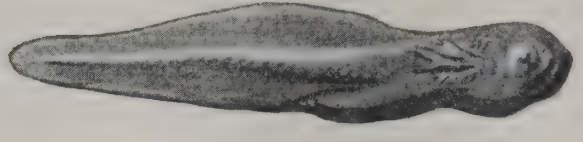

Figure 162.—A Tadpole just hatched.*

Directions to the Pupil

(1) Repeat your observations on the developing eggs and make drawings as before.

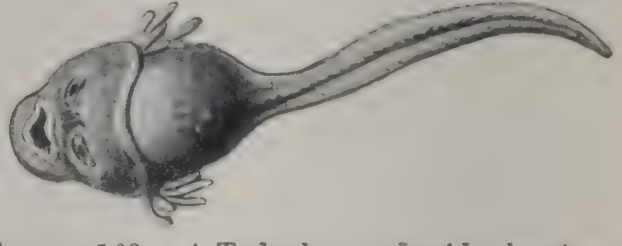

Figure 163.—A Tadpole—underside showing gills and mouth—3 days after hatching.

* Two days after reaching the stage shown in figure 157.

Part II—A Developing Chick (*continued, 2nd Investigation*)

Preparations for Work

Hen's eggs that have been incubated for three days will be required.

Directions to the Pupil

(2) Open the egg as before.

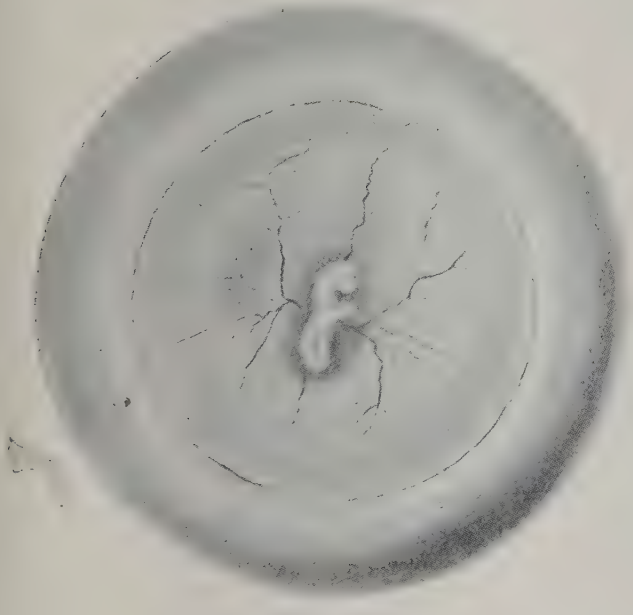

Figure 164.—A developing Chick, three days old.

Refer to your sketch made at the last lesson and describe the changes that have taken place. Sketch also the developing chick.

Is the chick alive? Why do you say yes or no?

(3) Answer the questions:—

(*a*) What is the use of the yolk and white of the egg?

(*b*) Why does the chick take longer than the frog to develop?

(*c*) Is the chick at this stage like anything you have ever seen?

(*d*) What parts can you see already partly formed?

Part III—A Spring Twig

Preparations for Work

Distribute horse-chestnut twigs, bearing a terminal, and one or two lateral buds.

Directions to the Pupil

(4) Compare the buds on the horse-chestnut tree with the drawing made in Lesson XIII, Part I, page 123. Make a note of any changes which have taken place and say whether the appearance of the buds has altered since the winter.

(5) Make a sketch of the bud at the end of the twig, drawing it carefully to scale. Note down the colour, consistency and number of the enclosing scales of the bud, so far as you can see from the outside.

Note:—The twigs must be put into water for use until next lesson.

Suggestions for Further Work in School

Other buds may be provided and the leaves carefully removed one by one until the ordinary foliage leaves, carefully packed away, and possibly a bunch of flowers, in the centre, are discovered.

Suggestions for Further Work out of School

It would not be amiss for some of the pupils to choose another bud growing out of doors on the tree and to make sketches of it for comparison with those taken from the bud kept in water.

The watching of a bud upon a tree may well lead to the study of the tree itself. It will veritably be found to form a little world of its own, and can easily be made the centre of many delightful observations. Various insects will be sure to feed on its leaves; a bird may build in its branches; all kinds of creatures will nestle under its bark or hide at the base of its stem. Added to all this will be the inter-relationships of the different animals, not to mention all the changes which life and growth bring about in the tree itself.*

* At East Stratton school each scholar has chosen a particular tree which is studied in the way indicated.

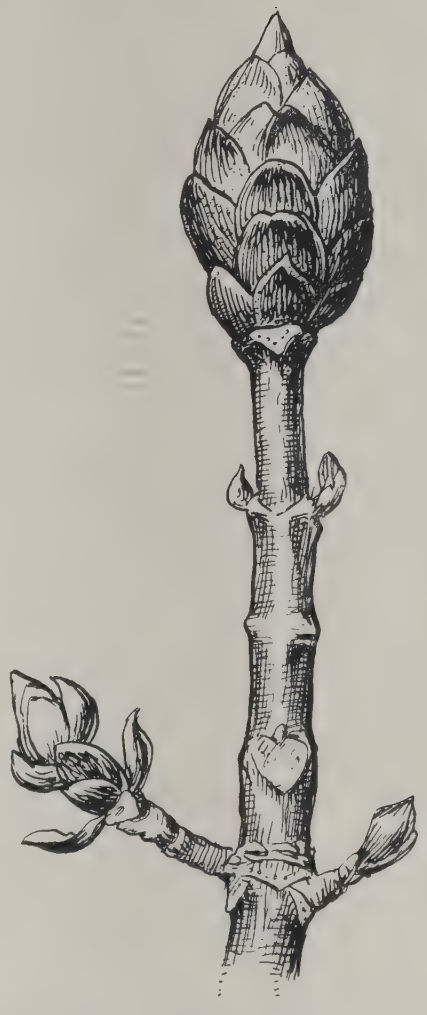

FIGURE 165.—Horse-chestnut buds.

CHAPTER XXI

OPENING BUDS

As trees are found everywhere and form excellent material for observation, in Chapter V (Part I) we departed somewhat from our custom of merely suggesting lines of work to give an illustrated account of leaves with indications as to their arrangement. By this means it was hoped to make the task of finding out the names of trees more easy.

We do not intend to go into detail with regard to buds. They will be found as a rule to be very characteristic of the trees which produce them, and they may be used a good deal in the identification of these. There lies before us a series of twigs, picked at random. No one would confound the long, thin, pointed buds of the beech with the small oval ones of the oak ; or the black scales of the ash with the handsome reddish-green coverings of the sycamore buds.

Before those whose taste leads them in course of time to consider more than mere form or colour, there opens out the botanical question of the relationships of the bud coverings to ordinary foliage leaves. Again, some buds, and commonly those of herbaceous plants, are without scales ; in others, such as the tulip tree, the wings on the stalks of the ordinary leaves, which are as yet unfolded, serve to protect them, while in such a tree as the false acacia the prickles which remain when the leaves fall practically enclose the young buds.

If we wait until the buds open as a matter of course, we shall

be able to see the various ways in which the individual leaves are protected, folded, and packed. We know beforehand which buds are sticky and preserved from the wet by resinous material, as is the case of the horse-chestnut, but now we shall be able to see how many scale leaves have been specially formed to wrap up the delicate foliage and, maybe, flowers within.

An interesting piece of work may be done in discovering the particular parts of the tree, which in various cases produce the flower bud. Such knowledge is of use to the horticulturist, and it will not be amiss to study fruit trees from the point of view suggested in connection with the garden. The cherry tree offers a very good example of branches specially concerned with the growth of fruit and content to increase but an inch or less each season for many years, unless some accident happen to their more rapidly growing brethren.

It may be advisable to urge upon the young photographer who wishes to make records from time to time, the necessity of placing behind his chosen bud a suitable background, not only for the purpose of making a contrast but in order to hide any branches and other objects which, being near at hand, would needlessly complicate the picture and obscure its meaning or, being out of focus, would give a blurred and ugly image.

The thorough student will see that all his pictures are made at the same distance from his subject and from the same point of view. Furthermore, as an opening bud of flower increases very much in size during the process, allowance must be made for this when taking the first pictures of the bud; these must necessarily be small compared with the size of the plates chosen.

Before leaving this subject we may allude to a method adopted by Mrs Dukinfield Scott for obtaining a series of pictures of the

same plant structures. A kammatograph is employed, which is an apparatus intended to take a number of photographs on the same plates with considerable rapidity, and to exhibit them again afterwards at a high speed so that movements may be reproduced. Plants only occasionally move quickly enough for the changes in the position of their parts to be perceptible, but the kammatograph forms a convenient way of taking a number of photographs from the same spot at frequent intervals, without disturbing the camera,* and what is more, the pictures taken at considerable intervals can when projected on the screen be made to move rapidly.

* Mrs Scott's methods were described by her in "The Annals of Botany," volume XVII. (September 1903), but since the above was written, a popular article by her has appeared in "Knowledge and Scientific News" (May 1904).

OBSERVATIONAL LESSON XXI

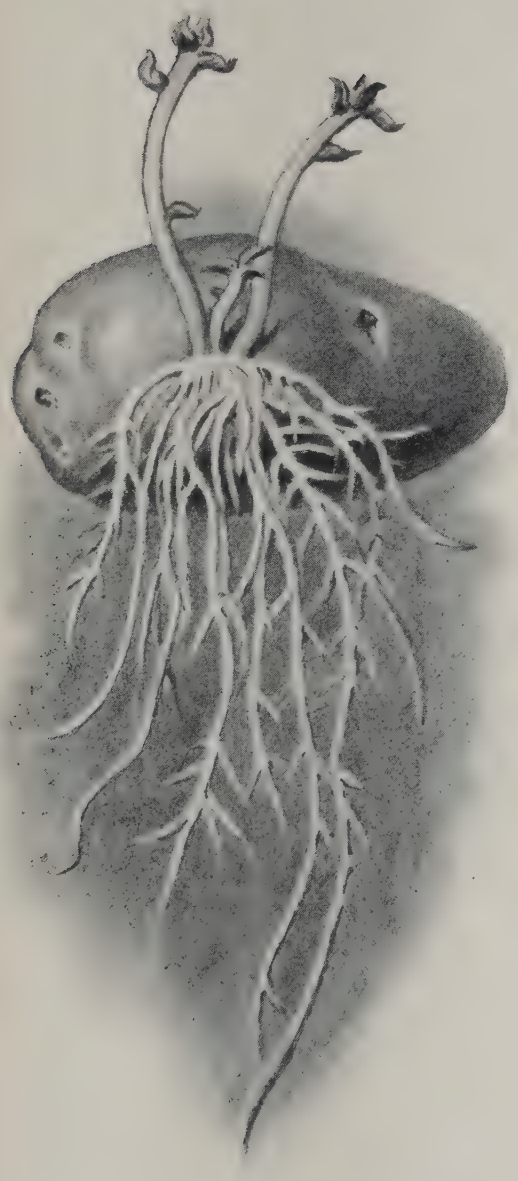

FIGURE 166.—A Potato showing young shoots.

PART I—A TUBER (*continued, 3rd Investigation*)

PREPARATIONS FOR WORK

Put ready the potatoes which are growing in boxes and in jars over water.

DIRECTIONS TO THE PUPIL

(1) Make records similar to those asked for in the last lesson (see page 20).

PART II—THE DEVELOPMENT OF A BUD

PREPARATIONS FOR WORK

The twigs used in the last lesson, and which have been kept in water, should be placed on the table.

DIRECTIONS TO THE PUPIL

(2) Make a sketch of the bud which you chose in the last lesson.

Describe the colour and texture of any other parts of it that have become visible. If possible, make a careful water-colour drawing, showing the bud at this stage.

FIGURE 167.—A Horse-chestnut bud opening.

PART III—AN EARTHWORM

PREPARATIONS FOR WORK

Dishes should be got ready containing damp moss free from earth, and large lob-worms placed therein.

DIRECTIONS TO THE PUPIL

(3) Record :—	Make :—	Leave :—
The length of the worm	A sketch indicating the "head" and "tail" of the animal	A space for a finished drawing
Its breadth		
Three observations as to its external appearance		

(4) Can you discover eyes, ears, and a mouth?

CHAPTER XXII

OBSERVATIONS ON EARTHWORMS

It is to be regretted that notwithstanding the publication, more than twenty years ago, of Darwin's beautiful researches on earthworms,* these creatures have hardly yet received the attention they deserve at the hands of naturalists. Every student of Elementary Biology has to dissect an earthworm and study its structure, yet how few of those who do so, know anything of its habits or otherwise think of it except as laid out in a dissecting dish. This indifference to the living animal as compared with the dead, is the result of causes which we are not disposed to discuss, but none the less is it to be regretted. The reaction in favour of the closer inquiry into animal life and habits hitherto ignored by some zoologists, which now seems to be beginning in many quarters, is all the more welcome. We make no apology for again emphasising the view that accurate knowlege of the structure of the organic world must go hand in hand with the study of living animals and plants, if a true education is to be gained thereby.

The study of earthworms may be carried on with both free and captive specimens. First let it be noted that common as these creatures are in cultivated and pastured lands, there are many places, such as sandy heaths, where they are very seldom, if ever, found. The actual cause of this is probably connected with the lack of moisture and suitable food in the shape of fine humus, but the reason

* "Vegetable Mould and Earthworms." John Murray & Co. (1881), 9s.

for their preference for old gravel walks and paths across fields is still to be discovered.

If, as Darwin suggested, compression of the soil is favourable to worms, nothing is easier than to imitate these conditions in a large box of earth, in which a known number of worms have been placed. A certain part should then be compressed, and it would be easy to find out whether, after a few days, this contained more worms than the rest of the box.

It is, however, as natural ploughs and cultivators of the soil that earthworms have excited so much attention. Their finely divided castings, familiar objects to everybody, are, by the action of wind and rain, blown and washed from the surface; and it has been shown that a layer of earth, ·2 of an inch in thickness, is every year brought up by earthworms, resulting, in many places, in a removal of over ten tons of soil per acre. This, in the course of ages, will amount to a vast deal, and is another instance of the important fact already alluded to in Part I, page 125, that the great changes which have taken place and are now taking place on our globe have been and are the result, not of sudden catastrophes but of small agencies continually at work. To quote from Darwin: "When we behold a wide turf-covered expanse, we should remember that its smoothness, on which so much of its beauty depends, is mainly due to all the inequalities having been slowly levelled by worms. The plough is one of the most ancient and most valuable of man's inventions; but long before he existed, the land was in fact regularly ploughed, as it still continues to be ploughed, by earthworms. It may be doubted whether there are many other animals which have played so important a part in the history of the world as have these lowly organised creatures." *

* Vegetable Mould and Earthworms, page 313.

It is thus brought home to us how from remote geological epochs earthworms have been at work, helping the atmospheric agents, wind and rain, to turn hard rock into fertile soil. As we write we have before us on the table a piece of quartzite of early Silurian age with

FIGURE 168.—Decaying vegetable matter pulled into the ground by a worm.

a well-marked worm burrow, showing that even in these remote times worm-like creatures burrowed in the sand of the sea floor.

It is well known that the earthworm lives in a burrow, except in much turned garden soil. There still would appear, however, to be a doubt as to whether healthy worms leave their holes except on rare occasions. Darwin affirms that they often do, but Mr O. H. Latter, in his recently published book,* takes the opposite view.

* "The Natural History of Common Animals," Cambridge Press.

Here, then, is an opportunity for anyone. Careful observation after dusk, often repeated, may help to settle this point. Furthermore, it would not be difficult to collect, from time to time, the worms seen crawling above ground in the daytime, which, if this observer is correct, ought to be either diseased, or the victims of the ichneumon fly. If on keeping them in natural conditions, they live a reasonable time, there can be no satisfactory cause for considering them to be other than healthy, and the question would be settled.

Some interesting observations may be made with regard to the odds and ends of vegetable remains which worms drag into their holes (see figure 168). In places where skeletons of the long leaf stalks of horse-chestnut abound, the exertions of the worms may cause the ground to bristle with them.

It remains for some ingenious photographer to obtain flashlight photographs of worms holding the sticks in their mouths and so reinforce Darwin's conclusions in this respect.

Again, something of the habits of worms, their senses, and intelligence, may best be studied by keeping them in pots, or better, boxes of earth. The earth should not be garden soil, but the turf from a field after the grass has been removed. If the nature student has studied the structure of the worm, he will realise that the phenomena of reproduction and the use of certain organs is still obscure; the only way to clear up the mystery is by keeping worms, from infancy up, out of contact with one another.

The interesting question of "aestivation" is another point to which the student may turn his attention. Just as many moisture-living animals and plants have special contrivances for withstanding the effects of drought, so the worm is able to go into a state of torpor in its burrow. How it is enabled to do this the nature student can easily find out for himself.

Finally, it may be mentioned for the benefit of those who are already acquainted with the structure of the earthworm, that the method by which the curious parasitic gregarine gets into the worm is still unknown. Is there an intermediate host? The clearing up of this interesting point would doubtless take a long time. It is for this reason probably that a not difficult piece of research has been left alone, though it is one which would well repay the trouble spent on it by bringing to light a process which has long baffled the theories of zoologists.

Only one or two naturalists have turned their attention to British earthworms, some of which, as they live under the bark of dead trees, are called tree worms; and there still remains much to be found out with regard to their number and distribution.

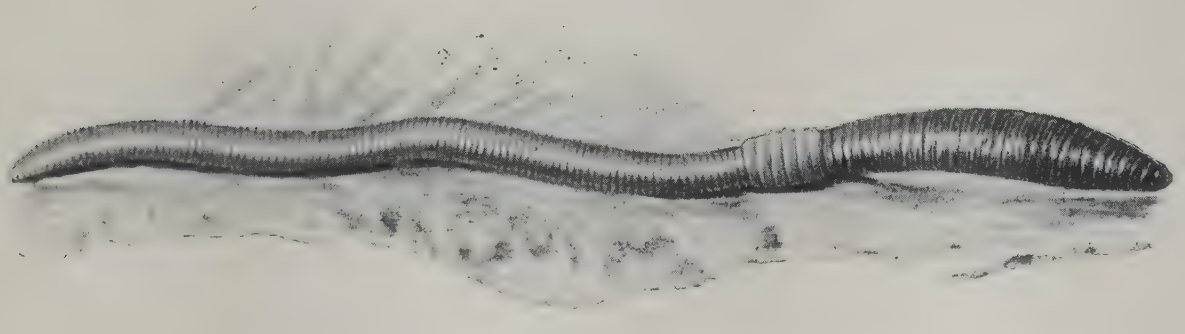

FIGURE 169.—An Earthworm.

OBSERVATIONAL LESSON XXII

Part I—A Tadpole (*continued, 3rd Investigation*)

Preparations for Work

The tadpoles will be required.

A preserved set of specimens showing the whole series of changes may be at hand.

Figure 170.—A Tadpole, 7 days old.

Directions to the Pupil

(1) Repeat your observations as before.

Suggestions for Further Work out of School

Owing to the impossibility of watching all the stages during school

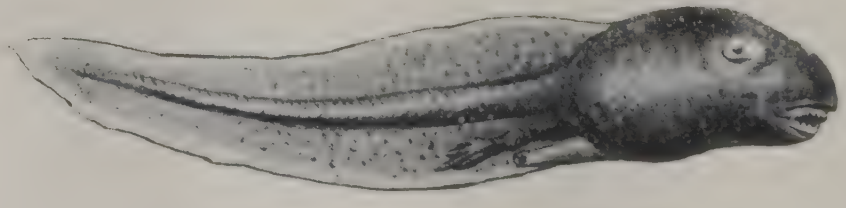

Figure 171.—A Tadpole showing the hind limb.

hours, it would be advisable to keep a few frog and newt tadpoles in your aquaria and compare the two.

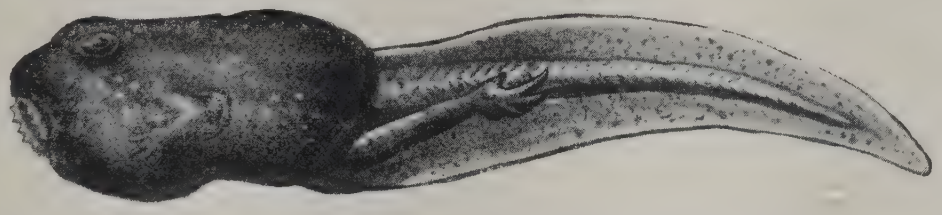

FIGURE 172.—A Tadpole showing hind and fore limb.

PART II—THE DEVELOPMENT OF A BUD (*continued, 2nd Investigation*)

PREPARATIONS FOR WORK

Distribute the horse-chestnut buds which have been kept in water.

DIRECTIONS TO THE PUPIL

(2) Repeat the operation carried out in the last lesson upon the bud (see page 36, paragraph 3).

FIGURE 173.—A Horse-chestnut bud opening and showing a bunch of young flowers.

PART III—A WOOD-LOUSE

PREPARATIONS FOR WORK

Some specimens of that common species of wood-louse which has the power of rolling into a ball, should be collected and placed in small loosely covered jars such as were recommended for use in the growing of moulds. (See Part I, pages 68 and 146.)

It will be necessary to adopt some means of keeping the atmosphere moist, within the jar. This may be done by inserting a strip of rag which has been wetted and made into a roll.

Directions to the Pupil

(3) Describe :—	Make :—	Leave :—
Colour Shape Number of joints Number of walking legs and two other features	A sketch of the animal as it appears when walking	A space for a coloured drawing

(4) Touch one of the wood-lice gently so that it begins to curl up. Wait until it unrolls again, and write a short account of the way in which this is done. Sketch the animal as it appears when rolled up with its back downwards.

Suggestions for further Work in School

Some of the other common species of wood-lice which do not roll themselves up into a ball may easily be obtained and compared with the "Pill wood-louse."

Figure 174.—A Pill Wood-louse rolled up.

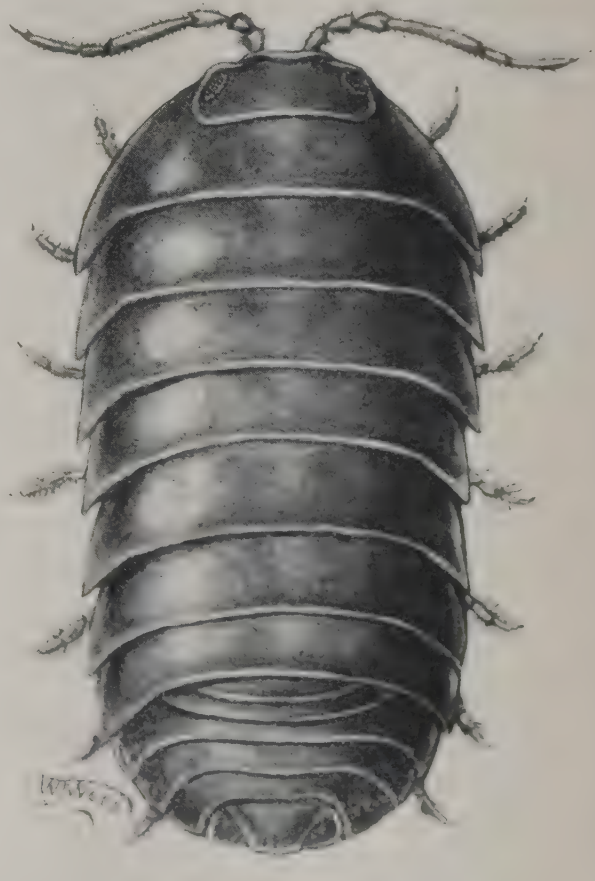

Figure 175.—A Pill Wood-louse crawling.

CHAPTER XXIII

OBSERVATIONS ON WOOD-LICE AND CENTIPEDES

It has been said that there is no British animal about which there does not remain something to be found out. What is more, there are plenty of creatures with regard to which very little is known, and in work which arises out of nature-study there will be all the more satisfaction if the observer feels that he is adding to general knowledge as well as to his own. We have already alluded to spiders' webs,* but there are plenty of spiders to be looked for which make no snares or only such as are inconspicuous. There are not many students of spiders in this country, and a lifetime might be spent in learning the peculiar habits of these animals.

There is a fascination also about finding any creature which the student has not met with before, but the pleasure is increased when the first record is made for the country generally.

If there are few who work at the animals just mentioned, there are still fewer who know anything of our wood-lice, centipedes, or millipedes (see figures 176 and 177). This makes it all the more possible that practically at the outset anyone who seriously devotes himself to such a tribe or class may be able to add species to the British list.† One of the reasons why spiders and centipedes have been neglected

* Part I, page 44.

† When attention was turned to the wood-lice of Eton, three species were discovered which had not been recorded for England.

is that they did not appeal to the old-fashioned collector, who cared little for anything which could not be preserved easily, and which, when kept in a dry state, had a handsome appearance in the cabinet, as is the case with butterflies, shells, and birds' eggs.

Most of the creatures which we have mentioned must be kept in alcohol, and while it is necessary to preserve some specimens for reference and in order to learn the names of the creatures whose habits are being watched, there will not be the temptation to collect merely for show.

Wood-lice are to be met with almost everywhere, and it would be easy to make observations upon them. Very few nature students have seen the interesting way in which these creatures change their skin, by shuffling off half their old coat at a time, so as to leave at least part of their bodies protected during the process.

The food of wood-lice is stated in some books to be animal. In others it is put down as being almost entirely vegetable, and from an economic point of view it would be interesting to know whether this is the case, as well as how far living plants are attacked by them. Wood-lice are given a very bad character by gardeners, but none of the latter seem to have caught the creatures in the act of damaging seedlings. It is possible that some other creatures are responsible for the injuries, and that the hordes of wood-lice to be found in greenhouses and "frames" take up their abode there because of the moist atmosphere rather than the young vegetation. It would hardly be a fair test to tempt captive wood-lice with seedlings, so that observations would have to be made upon specimens still at large, though, as in all probability the creatures feed principally at night, there are certain difficulties to be surmounted.

Wood-lice, and particularly those of the open country, offer

opportunities for the study of colour variations in common with other groups, and it is only a long series of careful and systematic notes as to various habitats and the characteristics of the individuals which dwell in them that will enable light to be thrown upon the matter. It is fairly easy to keep wood-lice in captivity, as all that is necessary besides supplying them with food is to prevent the atmosphere from becoming so dry that they cannot breathe. The

FIGURE 176.—A Centipede.

gill-like breathing organs of wood-lice can only act in moist conditions. Some simple but useful experiments would show whether light or its absence affects in any way the colour of these creatures. It is said that the handsome pink wood-louse has not its brilliant colour when it lives in the dark.

The females of some species are said to have eggs or young ones in their brood pouch at most times of the year, and it would be worth while to make careful records in order to discover whether other kinds have not more restricted breeding seasons.*

One British wood-louse is an inhabitant of ants' nests, and those

* Messrs Duckworth & Co. will shortly publish a monograph of British wood-lice, containing plates with enlarged figures of all our species.

who keep formicaria might be able to throw some light upon the question as to whether these creatures make themselves useful to the ants or not.

There is also plenty of work to be done with regard to the carnivorous centipedes and vegetarian millipedes. The life histories of but few are known. The young of millipedes, in particular, are not always born with the full complement of legs, and the process by

FIGURE 177.—A Millipede.

which these grow should be an interesting one to follow from a purely observational point of view. Some centipedes are luminous at night, and the exact reasons for this are still to be found out.

There are few classes of animals which, if made a hobby of, would better repay the young collector who seeks to make records of distribution as well as to study habits than the myriapods.

In the spring insects appear, which, later on in the year, are seldom, if ever, to be seen. The large bee-fly with its long straight proboscis, which flies about with marvellous rapidity on the first really sunny days, is a case in point.

Among forms that make their appearance early are some of the smaller wild bees, and, later on, the life histories of other insects may be followed. The cuckoo-spit insect is common enough, and is a good example of one which does not change very abruptly during its growth. The eggs will no doubt require very careful looking for, but the froth which is exuded by the young and wingless insect is very conspicuous. Specimens should be examined from time to time. At last a day comes when the final change of skin takes place. A frog-hopper now endowed with wings appears, and the froth dries up, revealing its old and empty coat. Many of the gall-flies, to be touched upon in Chapter XXXIII, are busy laying their eggs in the spring, and at this time also the insects whose grubs prey upon the larvae of the gall-fly, are actively seeking the latter.

Turning once more to spiders, we should mention that the water-spider can easily be induced in the early months of the year, to spin its silken "bell" beneath the water and fill it with a silvery globule of air. Any small glass jar will do, though the narrow flat-sided jars used for museum specimens are very convenient, as the spider can be watched more successfully. Of course some fragments of water-weed must be put into the miniature aquarium, to form the foundations of the "bell."

CHAPTER XXIV

Work for the Easter Holidays

PHOTOGRAPHS—NATURE CALENDARS AND NOTE-BOOKS—SURVEY MAPS—COLLECTIONS

Photographs

The owner of a camera will be able, as suggested in Chapter XXI, to secure in the spring, series of pictures showing the appearance of flower and leaf-buds in different stages, illustrating more or less completely their methods of growth. It may also not be too late in the Easter holidays to obtain pictures of trees without their leaves, while such as produce their blossoms before their foliage appears can at this time be taken in flower. A few birds' nests will no doubt be found which will serve as models, and photographs of clouds may also be made as at other times.*

Nature Calendars and Note-Books

Some nature students will find the keeping of a nature calendar, year by year, an unfailing source of interest. Such a record differs somewhat from the ordinary nature note-books, in that an endeavour is made specially to record the times of appearance or disappearance of animals, and of the opening of flowers, the formation of fruits, and such like occurrences. The greater the trouble spent upon the work, the more valuable will it be, and in the course of years a con-

* See Appendix.

siderable amount of material will be obtained upon which it will be possible to base some general statements. The entries will doubtless be brief, especially if they are not confined to some particular class of creature (see Part I, page 16, Bird Calendar). The note-book, with its sketches and inserted photographs, will supplement the whole calendar, or such parts as may most interest the particular observer.

One of the most useful combinations of calendar and note-book is one which deals with the life histories of insects, such as have been alluded to at the end of Chapter XXIII. The times at which various changes of egg into caterpillar, caterpillar into chrysalis, chrysalis into adult insect, form the basis of the calendar, while description of methods of feeding, devices for protection, changes in appearance, will go far to fill the nature note-book.

Survey Maps

What the nature calendar does for time, the survey map will do for distribution. Of course an original map should, if possible, be made, but it would be something to record the occurrence of plants and animals on an ordnance map,* or a copy of one. It is possible to confine attention to particular forms, and one variety of the survey map can have special reference to what is called a birds' nest census. All the birds' nests in a certain district may be recorded on the map, and a note-book kept with it, in which details of the success or failure of the attempt on the part of the old birds to rear their young may be set down. In addition to records of nests built in the ordinary course, the results of putting up nesting boxes (see figures 159 and 160),* for the purpose of attracting birds, may be further added. (See also Part I., Introduction, page 5).

* See Appendix.

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Collections

By Eastertide it will be time to seriously hunt for some of the smaller animals. Centipedes and millipedes will be active and readily found under stones and logs. Wood-lice, too, and some spiders, will be discovered. A few specimens should be killed by dropping them directly they are found into twenty-five per cent. or thirty per cent. spirit, when they will gradually become narcotised, and die. If it be desired to mount them (see Part I, figure 115), they will be found at any time during the following few days in an excellent condition for the purpose, that is to say, sufficiently limp for their body, legs, and antennae to be arranged in suitable positions, and gummed to the glass upon which they are to be fixed.* In any case, in the end, the specimens obtained must be preserved in stronger (seventy per cent.) spirit. A paper label, on which the date and place of capture should be written with *lead pencil*, must be dropped into the wide-mouthed bottle or jar used to contain them.*

It is of course impossible to consider everything that might be searched for at the beginning of spring, but we might allude to land and fresh-water shells, the former being tempted from their winter hiding-places by April showers. We should not forget, however, that many of the mosses among plants, even in the coldest weather, bear their characteristic capsules, and the slime fungi considered already (Part I, Chapter VI) may also be obtained.

* See Appendix.

OBSERVATIONAL LESSON XXIII

Part I—A Tuber (*continued, 4th Investigation*)

Preparations for Work

Distribute the potato tubers.

Directions for the Pupil

(1) Write down :—	Make :—	Leave :—
As many points of likeness between the potato tuber and the bean seedling as you can. Indicate any differences also.	A sketch of the tuber as it now appears	A space for a finished drawing

Fill up the boxes with earth to encourage the formation of young tubers.

Part II—A Wood-louse (*continued, 2nd Investigation*)

Preparations for Work

Obtain wood-lice and confine them as before (see page 43).

Directions to the Pupil

(1) Turn your attention to the underside of the wood-louse and discover other structures to be seen there in front and behind the ordinary legs.

Part III—An Opening Flower

Preparations for Work

Any flowering plant in a pot which bears a young but fairly large-sized flower-bud may be taken as material for this lesson. Some species of lily would do well.

Figure 178.—A Lily bud.

Directions to the Pupil

(2) Make a note of two or three special characteristics of the plant before you.

(3) Carefully measure the length of the stalk which bears the flower bud. Make a drawing of the latter carefully to scale, describe its general appearance, and add the date.

Part IV—Silkworm Eggs

Preparations for Work

Eggs of the silkworm which have been deposited on pieces of paper or cardboard should be handed to the pupils.

Directions to the Pupil

(4) Make a careful sketch of one or two of the eggs of the silkworm and date your drawing.

During the days that follow, keep an eye upon the silkworm eggs, which should be placed in a small box to which air is admitted by means of pin holes. If possible, the hatching of the eggs should be seen, and when this has taken place young leaves of the mulberry (or, if this is not possible, those of the lettuce) should be put within the reach of the tiny caterpillars. After the young insects have crawled on to the leaves the latter should be placed in open trays. Fresh leaves to replace those which are eaten or become faded must be provided from day to day.

FIGURE 179.—Silkworm Eggs.

CHAPTER XXV

Flowering Plants

THE PROPER STUDY OF FLOWERING PLANTS—PHOTOGRAPHS OF FLOWERS—THE PRESERVATION OF PLANTS

The Proper Study of Flowering Plants

There will always be those who pay particular attention to flowering plants, and whose work will carry them no further than to learn the names of the flowers which they find in the field or hedgerow, on moor, or in the shaded woods, and to keep specimens of their finds. Flowering plants form, however, but one group of the living world, and the days are gone by when their study was synonymous with botany. Leaving, however, on one side the mere classification of flowering plants, and their structure as now studied in the laboratory, we may devote our attention for a few moments to considering another way in which the nature student may approach them. We have already alluded to their fruits in connection with the dispersal of seeds, the varying shapes of the leaves of trees have claimed our attention, and we shall discuss among other things the devices they adopt for their protection and their methods of climbing. There are, however, many other points of view from which they may be examined. The size and shape of the seeds of our wild flowers might well come in for consideration, and the reasons for this or that peculiarity deduced from observations. There is, moreover, still something to be found out with regard to

the methods of their germination and the time during which they may retain their powers of growth.

The extent to which flowering plants can modify themselves to suit circumstances is very considerable, and the nature student might do worse than to compare the size of the leaves of plants of the same species which grow respectively in bright light and in the deep shade, or to note the effects of damp soil upon a plant that usually lives in a dry situation and contrariwise. There are plants which possess the power of changing their parts very materially, according as these grow in air or water; for instance, the leaves of the water-buttercup, which come above the surface of a pond, are very different from those which remain below, and should the plant happen to grow upon the margin, away from the water, the second kind of leaves will not appear at all.

Again, there are such things to study as the methods which plants adopt in order to protect their pollen; the movements they make to attain this and other objects; the whole series of snares and traps to allure and to digest insects, and the means, often hidden from sight, by which they steal supplies from their fellow-plants. Still other matters remain, and some of these, such as the question of fertilisation and the responses which plants make to the attentions of gall insects, are mentioned in this book. Beyond these again there are further relationships between plants and animals which may occupy the attention of the general student.

Those who wish, however, in the end, to specialise upon flowering plants, should first of all gain some knowledge of the plant-world as a whole, or better still, of animals also, and then proceed not only to consider the classification and habits of their special favourites, but also their internal structure and the ways in which they work and grow and live.

Photographs of Flowers

It is becoming more customary to collect photographs of birds, instead of shooting them, or of their nests without robbing them,* and this is not because a well-stuffed bird or a blown egg does not give an adequate idea of its original form and colour. The ordinary pressed plants, on the other hand, however, leave a great

Photograph by Henry Stevens.

Figure 180.—"May."

* Through the example of Mr Richard Kearton and others.

deal to be desired, and good ordinary photographs will serve as excellent records of form, and if one does not mind losing some of the more delicate tints and their nicer gradations, a fair representation of colour in the form of the transparencies invented by Mr Sanger Shepherd can, with the expenditure of some trouble, be obtained.

The possibilities of the ordinary photograph are, however, pretty considerable, as will be seen from some of the work of Mr Henry Stevens, which through his kindness we are able to reproduce (see figure 180).

Drying Plants in Natural Form and Colour

If considerable space can be given to the collection (and in a dry position), or small series of specimens only are required to illustrate structure and habits, a method of drying plants without flattening them, and in many cases without destroying much of their colour, may be employed.

In the simplest form a layer of clean and perfectly dry sand is put at the bottom of a box big enough to hold the part of the plant to be preserved, leaving some space above and around it. More sand is now taken and skilfully placed in the box to fill all interstices of the plant, so that it is gradually buried with all its parts retaining their original relationships. If much work is to be done, it is possible to construct a sort of "hopper" from which the sand may be conducted by means of a flexible tube to any place and in such quantities as may be desirable. At last when the plant is well hidden, the box is placed in a dry place such as a kitchen cupboard for a week or so. After this time has elapsed, the bulk of the sand is allowed to fall away by tipping the box, and what may

remain attached to the specimens is brushed away with the utmost care. A modification of the process may be made by using hot sand, and by this means advantage is gained, as the more rapid the drying of some parts the better the colours are retained, though the plants are more brittle afterwards.

Sand is not by any means, however, the only material used for the purpose. A mixture of one part of lime to three parts of plaster of Paris may be employed. Experiments ought to be made with a number of substances, as improvements are possible. For instance, of recent years the British Botanical Association has produced very successful work (see figures 181 and 182) with the earth (kieselguhr), which, when saturated with nitro-glycerine, forms dynamite. The earth is, however, subjected before its use with plants, to a special treatment, the details of which have not been made public. What is required, is a material or mixture which has the necessary weight combined with sufficient powers of absorbing moisture, and which does not stick unduly to the leaves and flowers. The specimens may be stitched to cards and kept in glass-topped boxes with tightly fitting lids. A more expensive method, more suitable perhaps for museums, is to place the dried plants in glass jars with hollow stoppers in which calcium chloride is placed, which will absorb all the moisture from the air in the jar and keep the specimen perfectly dry.* In this case the colours preserved in sand will keep for a very long time.

If the older method of pressing flowers be adopted, care should be taken to choose a form of press which allows of the free entrance of air,* and the drying paper should be frequently changed. When the plants are mounted they should not be stuck permanently to cards, but attached by strips of gummed paper or stitches, so that they can be placed on clean backgrounds at any time. Care should be taken

* See Appendix.

also not to arrange all the specimens in the middle of the paper, if a herbarium is contemplated, or a mound may be produced instead of an ordinary pile when the sheets are placed one above the other.

By the courtesy of the British Botanical Association.

FIGURE 181.—A dried Fritillaria plant.

FIGURE 182.—A dried branch of Alder.

Representatives of the various genera should be kept together in such a way as to allow for rearrangement and the insertion or abstraction of specimens.* Covers such as those designed for the Eton Nature-Study Note-Book are to be recommended, for by the simple manipulation of the ends of a lace all that is required may be effected.

* See Appendix, Part I, p. 148.

OBSERVATIONAL LESSON XXIV

Part I

An Opening Flower—(*continued, 2nd Investigation*)

Preparations for Work

The plants previously used, should be placed in front of their respective owners.

Directions to the Pupil

(1) Record the length of the flower stalk, the increase in size of the bud, and any changes in the appearance of the latter. Make (and date) a sketch, to the same scale as before.

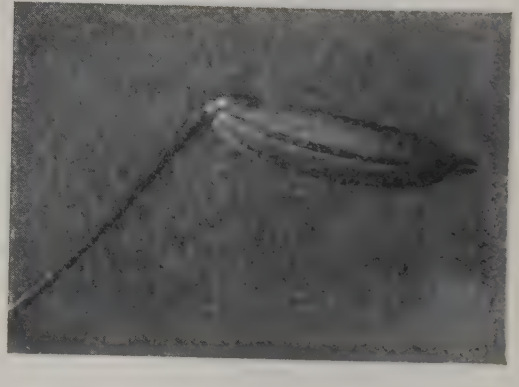

Figure 183.—A Lily bud swelling.

Part II—A Silkworm

Preparations for Work

Distribute the trays containing silkworms.

Directions to the Pupil

(2) Write down :—	Make :—	Leave :—
The age, size, colour, and as many other features of the caterpillar as you can, after having examined it very carefully from all points of view	A sketch of the young silkworms as they appear on the leaf, correctly showing, by means of an outline, the relative sizes of the two	A space for a careful drawing, which should be made and coloured at leisure

Suggestions for Further Work out of School

It is hardly necessary to point out that all the subjects which are used for continued observation may be watched with advantage during the time which elapses between two lessons. It is necessary, almost, if the process which the silkworms go through of changing their skins is to be seen, for the pupils to watch them from day to day.

Part III—A Bee

Preparations for Work

Each pupil should be supplied with a living worker and drone bee. The glasses used in mould-culture can be used for this purpose. The teacher should have one or two "queens" at hand for comparison. Hand lenses may be used with advantage.

DIRECTIONS TO THE PUPIL

(3) Examine and draw both of the bees, leaving a space for a more elaborate sketch.

(4) Write down as many points of difference between them as you can see.

FIGURE 184.—A Drone Bee.

(5) Compare both with a "queen," and state how each of them differs from her.

(6) Write a few lines to let it be seen whether you have watched drones and workers outside the hive and noticed what they do.

CHAPTER XXVI

NOTES ON OBSERVATORY HIVES

WITHIN ordinary hives it is almost impossible to see what the bees are doing. Of course a careful beekeeper will at times have to take out his frames and examine them, after subduing his bees with smoke; but in order to get any idea as to how the bees work, it is necessary to have some kind of observatory hive indoors. This can easily be made and so arranged that the bees can have free access to the outside without any chance of getting into the room.

FIGURE 185.—An Observatory Hive.

A useful form of observatory hive is shown in the illustration (figure 188). It consists of a wooden framework about two feet six inches high, one foot long, and three inches broad, with glass sides. At the bottom there is a slit-like exit for the bees, and attached is a piece of glass tubing which acts as a gangway to the outside.

One side is hinged so as to open freely. The top of the frame consists of perforated zinc for ventilation and feeding.

The frames supporting the wax for the bees to work upon can be hung one below the other and supported by small knobs of woodwork.

The hive can conveniently be stood on a table near a window. The particular arrangement for allowing the bees access to the outside must depend on circumstances. If the window panes are small, it will be found advisable to cut a hole in one slightly larger than the glass tube which forms the exit.

A smaller hive (see figure 186) may be made as follows :—*

"Choose a partly filled section of honey and drive small brads into the corners, letting the heads stick out one-half of an inch below, for it to stand on, and a quarter of an inch at the sides to ensure room for the bees to pass between the section and the glass that is to cover it. Next cut pieces of glass the right size to make a glass case to slip over the section. The front glass must be cut one quarter of an inch short to allow space for the bees to go in and out at the bottom. Fasten then sheets of glass together with half-inch strips of black cotton cloth and glue." Both the section and its case should be stood on a board about six inches wide, and long enough to project ten inches beyond the hive. The hive may now be placed near a window and arranged thus :—"Lift up the sash an inch or two and fasten a narrow board upright under it. In this cut a hole an inch wide by half an inch deep, through which the bees can walk. Finally, make a wire tunnel to fit tightly between the hive and the board under the window sash to prevent the bees coming into the room."

In any frame hive it will be possible to see the eggs, larvae, and pupae (see figures 187, 188, and 189) at the right season. The best time to watch the bees at work in the observatory hive is on a bright

* "Nature-Study and Life." By Clifton Hodge. Ginn & Co. Price 7s. 6d.

summer morning, when the majority of the workers are abroad and only return from time to time to unload their supplies of pollen, honey, and other substances. It will be found, however, that many remain at home, and it is interesting to note the perfect unanimity and good fellowship that reigns. The duties performed by the workers are so manifold that it would be useless to try to mention a small fraction of them. We would specially direct the attention, however, to the comb-builders and nurses, and though this is not always to be seen, the behaviour of the queen herself. It is said that the comb-builders are of slightly smaller size than the other workers, but we have not been able to convince ourselves that this is true. Of special interest is the way in which the baskets on the legs of the pollen gatherers are emptied and the contents stored away. It will be generally found that a "nucleus" put into an observatory hive will not acquire sufficient size to swarm, though queen cells may be formed, and princesses developed within them. The death of these unfortunates and the rage of the queen herself which their presence in the hive excites, till the workers allow her to murder them, can at times be seen in an observatory hive. As soon as the queen's battle cry is heard, usually towards evening, and the answering challenge comes from the imprisoned princesses,* the tragedy may be expected.

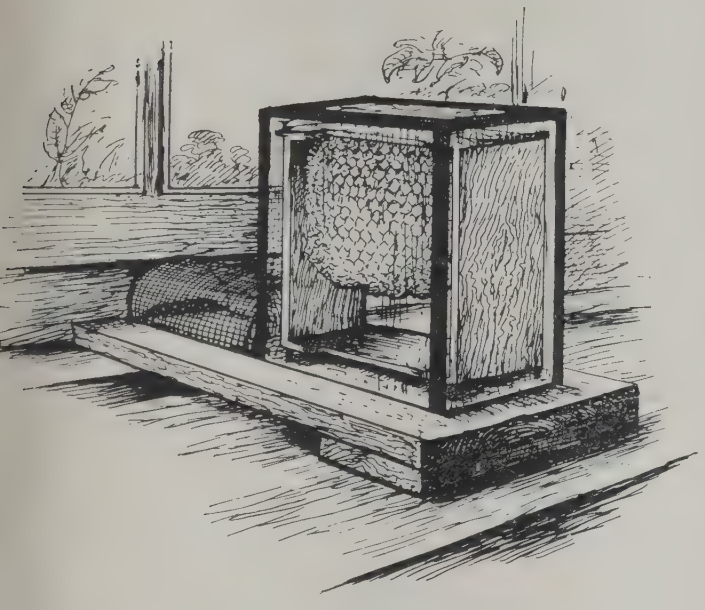

FIGURE 186.— A Nucleus Hive.

* We must confess to not having ourselves heard this latter sound.

Finally, if the student has time at his disposal, there is much that he may do besides looking out for the special points which we have suggested.

FIGURE 187.—The egg of the Honey Bee.

If one or more queen cells are formed, it is well to remove the old queen, and allow one virgin queen to emerge from her cell. On the ninth day after her appearance, generally about 10 A.M., she will be seen to leave the hive for her nuptial flight. The behaviour of the bees at this moment and on her return should be watched, since observers differ in their accounts as to the "send off" and welcome home that she receives. To all bee-keepers, and in fact to all those who care to read about these insects, we may recommend Maeterlinck's "Life of the Bee," perhaps the most remarkable book of its kind published in late years. Though to some extent fanciful in places, for instance, as regards the description of the queen's nuptial flight, the account of bee-life is told with such keen insight and descriptive power that the reader will be caught by the author's enthusiasm for his subject. If the nature student is not a practical beekeeper, and does not know how to raise a nucleus swarm, he should buy a copy of the *British Bee Journal* early in June, and order a nucleus swarm from advertisements which he is sure to find. This will consist of two or three frames covered with worker bees, and one queen, and should be put into the observatory hive as

FIGURE 188.—The larva of the Honey Bee.

soon as possible. If the bees be subdued slightly by smoke before the operation, no danger from stings need be apprehended. The bees should for the first few days be fed with syrup,* and then allowed to shift for themselves. Care should be taken that the bees have easy access to the open air. When not under observation, they should be kept covered up, as bees dislike working in the light, and will almost certainly build a waxen screen against the glass to hide the combs. When the bees are in full swing, the great variety of their movements and labours will form an almost irresistible attraction. There need be no fear, moreover, of the bees swarming in the summer, unless the hive be very small. As winter approaches, the bees should be united to a weak colony in an ordinary hive.† If left in the observatory hive, they should be given syrup or candy, and be packed away so as to keep at a uniform temperature if possible, but the probabilities are that they will die, however much care be taken, there being not sufficient numbers for wintering properly.

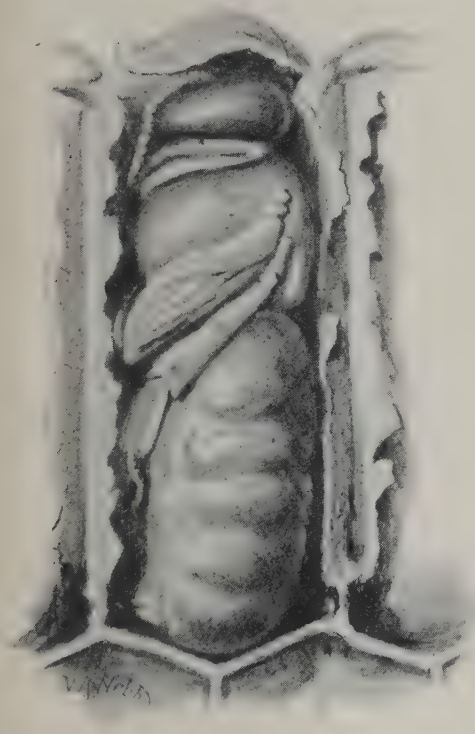

FIGURE 189.—The pupa of a Drone in its cell.

The actual way in which bees bring about the fertilisation of flowers can only really be learnt by direct observation, in the garden or fields. The wonderful mechanism which many plants have to ensure the carrying away some of the pollen by a visiting insect, makes it clear how they depend entirely on insects for cross-fertilisation.

It is noteworthy that no traces of flowering plants are found

* See Appendix.

† See "Beekeeper's Guide Book."

fossilised until long after the appearance of many orders of flying insects.

It is best to watch one or two particular insects, such as the honey bee and humble bee, and note what flowers they visit.

FIGURE 190.—A Humble Bee visiting Snap-dragon.

There are certain flowers, for instance, the crown-lily, to which the bee does not go, though apparently it is full of nectar. What, then, is the use of this nectar, and what insects does it attract?

A catalogue of plants and their insect visitors can be made in which the time of opening and shutting of the corolla and the feeding-time of the insects may be compared together.

There can be no doubt that the changes of structure of many flowers and insects directly depend on each other.

The salvia and snap-dragon (see figure 190), for instance, seem to be specially constructed for the honey bee and humble bee respectively. Other instances should, if possible, be observed, and noted.

The story of the vanilla is probably well known to many, but with it we may aptly close this chapter. The fruit of this plant is so largely used for flavouring chocolate that its cultivation has been tried in many places. It was found, however, that although the plants lived and throve in their new quarters, they bore flower but never fruit. The flowers remained sterile because the pollen could never fall into the stigma and so fertilise the ovules. A young slave, a native of Réunion, in 1841, discovered a way in which by inserting a small bamboo point into the flower, fertilisation could be brought about, and a number of flowers were made capable of bearing fruit. In the original home of the vanilla, in Central and South America, this office is performed for the flower by a small bee. Should the student wish for further information on this highly interesting subject, the best book for him to consult is Darwin's "Fertilisation of Orchids," but it must not be forgotten that these written accounts, fascinating as they are, should not stand in the way of actual observation on the part of the student himself.

Lastly, it should not be forgotten that just as many plants have an elaborate apparatus for securing cross-fertilisation by means of insects, so, as Belt was the first to point out, "Many flowers have contrivances for preventing useless insects from obtaining access to the nectaries."* The leaf cup of the common teazle, the slippery surface of the petals of snow-drop and cyclamen, the hairs and sticky secretion of many plants, all serve the same purpose.

* "A Naturalist in Nicaragua," by Thos. Belt, pages 131 and 133.

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OBSERVATIONAL LESSON XXV

Part I—A Growing Tuber (*continued, 5th Investigation*)

Preparations for Work

The boxes containing the growing potatoes will be wanted

Directions to the Pupil

(1) Note any changes in your potato plant.

Part II—An Opening Flower (*continued, 3rd Investigation*)

Preparations for Work

Put ready the plants made use of in the two previous lessons.

Figure 191.—A Lily bud about to open.

Directions to the Pupil

(2) Record, as before, the size and appearance of the flower bud. Date your sketch.

Part III—A Silkworm (*continued, 2nd Investigation*)

Preparations for Work

Trays of silkworms should be at hand together with a supply of fresh food.

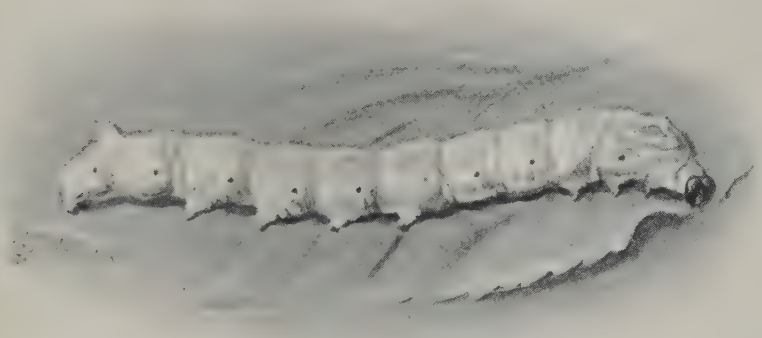


Figure 172.—A Silkworm Caterpillar.

Directions to the Pupil

(3) After having noted the increase in size in your caterpillars, write a brief description of the way in which they feed, if necessary giving them fresh leaves, in order to tempt them to eat.

Part IV—A Bee (*continued, 2nd Investigation*)

Preparations for Work

Drones and worker bees (dead) should be distributed.

Directions to the Pupil

(4) Take the worker bee in your hand and look more carefully at it than you were able to do in the previous lesson. Treat the drone in the same way and add to your descriptions written down in the last lesson.

(5) Gently press the abdomens of both bees and note the difference. Make drawings as before.

CHAPTER XXVII

THE MAKING OF A FORMICARIUM

MANY species of ants may be kept without difficulty in captivity. Nests can occasionally be bought from dealers,* but it is always better and much cheaper to make one for oneself. The common yellow ant is a suitable species to begin with. The whole nest should be dug up, and the ants and earth all brought home.

A simple way of making a formicarium † is to get a large photographic printing frame and a tin baking dish into which it will easily fit. In the former are placed two sheets of glass cut exactly to fit it, and kept a quarter of an inch apart by little strips of wood which neatly join at the corners of the frame. Between the sheets of glass are to come the ants and the finely divided soil from their nest.

Legs are attached to the frame, or this is laid on a little stand in the dish, so that it is well above the water with which the latter is to be half filled. Finally an opening is made through the frame into the nest at one end, so as to communicate with a little ladder reaching to the water, down which the ants can go to drink. The back of the printing frame is replaced when observations are over, and held in position by the springs provided for the purpose.

The yellow meadow ant is a species which Lord Avebury compared

* See Appendix.

† The method described is employed at the Stepney Borough Museum by Miss Kate Hall.

with the others, saying that it represents "a distinctly higher type of social life; they show more skill in architecture, may literally be said to have domesticated species of aphides, and may be compared

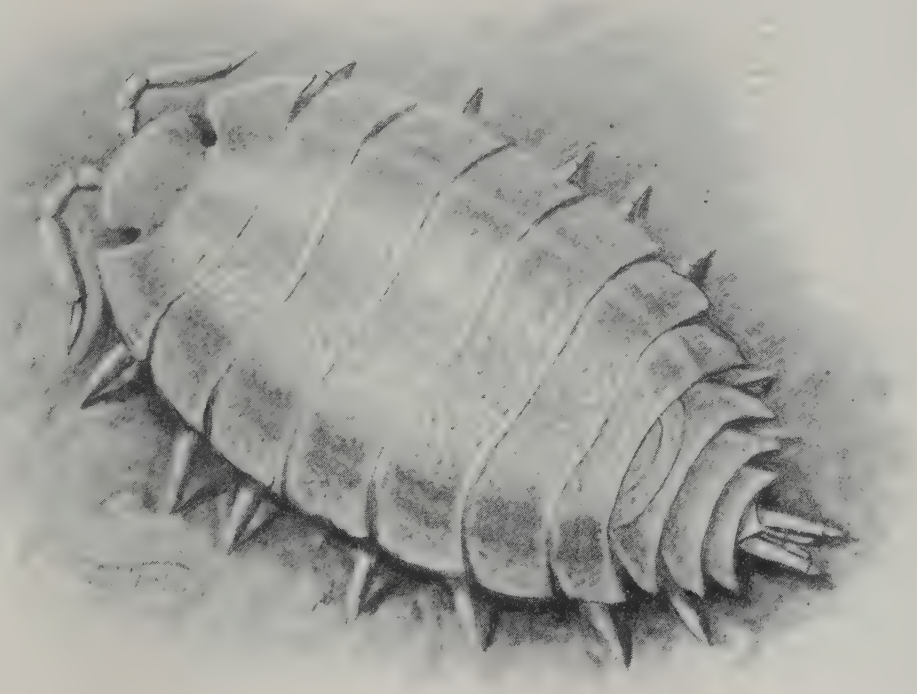


FIGURE 193.—The Blind Wood-louse that lives in ants' nests.

to the pastoral stage of human progress—to the races which live on the produce of their flocks and herds. Their communities are more numerous; they act much more in concert; their battles are not mere single combats, but they know how to act in combination."*

In the southern counties a red ant is to be found, which may also be kept in captivity along with some of its slaves or

* "Ants, Bees, and Wasps," International Science Series.

"helps" (a brown species). The species which are completely dependent on their slaves do not occur in this country. Provided with one or two nests, the student may devise a course of observations as to the habits of ants that may last him for years. Much patience and the methodical writing down of what has been seen are necessary, if anything like a trustworthy piece of work is to be accomplished.

It must not be thought, however, that new discoveries can be made off-hand. Should the possession of an ant's nest rouse a wish to have more than a superficial knowledge of the ways of ants, the student should read what has been done, and there is no book that can be more profitably consulted as an introduction to the study of ant life than the work by Lord Avebury, quoted above.*

The Inhabitants of Ants' Nests

We should be omitting one very remarkable point in the economy of ants if we were to neglect to say something of the "domesticated animals," "hangers on," and "scavengers," whose abode is either in the near neighbourhood of the ants' nest or actually inside it. Ants, it is well known, visit certain species of green-fly which suck the juices of plants, in order to fetch the sweet exudation from their bodies which has been called "honey-dew." The work of some ants, however, carries them further: they may collect and tend the eggs of their "cows," or keep herds of similar insects which feed on roots in their underground galleries (see figures 194 and 195).

* We might here offer a warning not to feed the yellow ant on the same syrup as is prepared for bees, containing napthol beta. Nothing but honey should be given to this species.

We have already alluded to the tiny white and blind wood-louse* which lives unrestrained in the nests of ants (figure 193), and other denizens in the shape of beetles and the small wingless insects called spring-tails may also be discovered. Of the former, perhaps Claviger is the best known. Quite blind, it is dependent on the

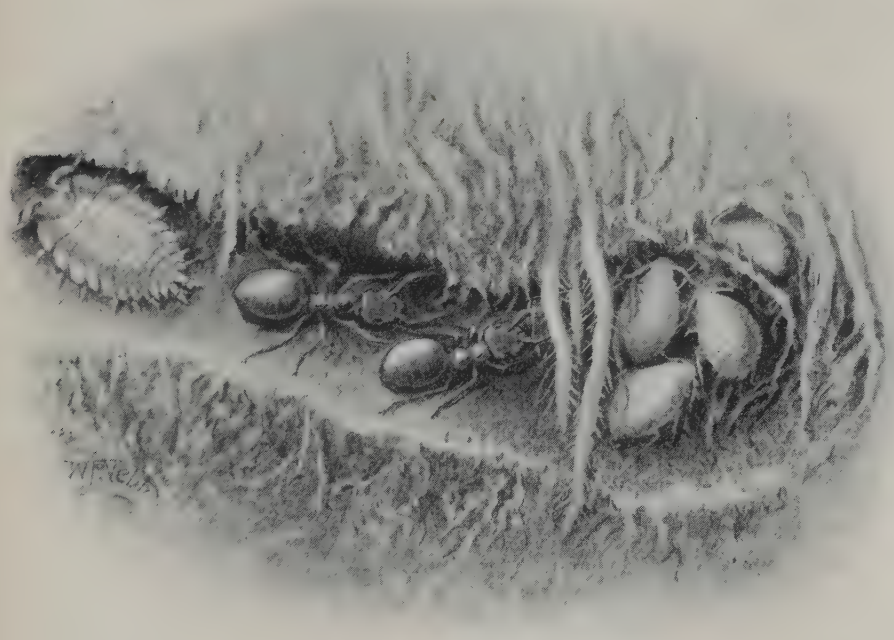


FIGURE 194.—A gallery in an Ants' nest with their "cows."

FIGURE 195.—An Ants' "cow" showing the underside and the proboscis for sucking the juices of plants.

ants for food, while they in their turn, as Müller has pointed out are very fond of sucking the tufts of hair with which the beetle is provided.

* Chapter XXIII.

OBSERVATIONAL LESSON XXVI

Part I—A Bee (*continued, 3rd Investigation*)

Preparations for Work

Some honeycomb in process of construction will be required.

Directions to the Pupil

(1) Sketch a piece of honeycomb, note down the depth and breadth of the cells, the number of sides to them, together with three other points with regard to the comb.

Part II—The Sun (*continued*)

Preparations for Work

The simple apparatus required for the observations upon the sun should always be ready, so that in this or any other lesson advantage may be taken of a day when the sun is visible.

Directions to the Pupil

Mark the position of the sun on the window and of the shadow of the window bar upon the floor.

Part III—An Opening Flower (*continued, 4th Investigation*)

Preparations for Work

For the last time, set out the plants used for the study of an opening flower.

Figure 196.—A Lily bud opening.*

Directions to the Pupil

(2) Make a careful drawing of the fully opened flower. Write down how much the stalk has grown in length since you first examined the plant.

(3) Describe fully the various kinds of parts which make up the flower. Draw these separately, and leave a space underneath your sketches in which to write the uses of each when you have been able to find them out.

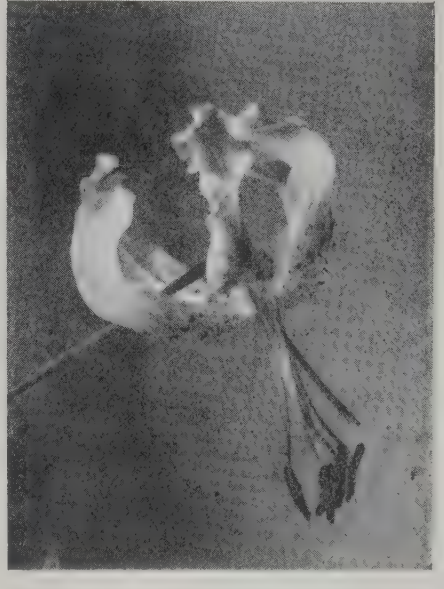


Figure 197.—A Lily flower.*

Suggestions for Further Work out of School

In a school garden the visits of bees and other insects to flowers should be noted, and the result of keeping these creatures away from some freely fruiting plant should be seen.

* Figures 178, 183, 191, 196, and 197 are from photographs by Wilfred Mark Webb.

CHAPTER XXVIII

THE REARING OF CATERPILLARS—PHOTOGRAPHS OF INSECTS COLLECTIONS OF INSECTS

The Rearing of Caterpillars

There are many British caterpillars which may be reared with but little more trouble than the silkworm. It is, however, necessary, as they have not been bred in captivity for hundreds of generations like the latter, to keep them in something which restricts their movements more than an open tray. A cage should be made which admits light and air, and has a false bottom through which the stalks of the shoots, on which the caterpillars live, can pass into vessels of water below.

A simple form may be described as follows:—

Take an ordinary box such as those in which soap is packed, and remove the top and bottom. Stand it on one of its sides and fix into it a shelf (so as to form the false bottom to which allusion has

Photograph by Wilfred Mark Webb.

FIGURE 198.—A Privet Hawk Caterpillar showing the bands which "break" the surface of its body.

been made) of such a width that it will exclude the caterpillars from the compartment below, and at such a height as will allow the vessels which contain the stems of the food plants to pass easily beneath it. One of what are now the sides of the breeding cage can be filled in with a sheet of glass, cut so as to exactly fit the inside of the box, but prevented from falling in, by means of small strips of wood. If the glass is to form the door, it can be kept in place by movable buttons. The other side can be covered with mosquito netting tacked on to the sides of the box, or if the entrance is to be here, on the inside of a frame of the same size as the glass. The inside is chosen so that the netting may touch the false floor, and an extra strip of wood may with advantage be fastened across the frame along the line of the floor to prevent caterpillars from pushing down into the lower half of the enclosure. More elaborate cages, made expressly, can of course be utilised, which, if they are to be used afterwards to contain the adult insects, should be covered with gauze all round. Holes should be bored in the false floor at convenient intervals, and after branches have been pushed through into the water below, the interstices should be plugged with cotton wool to prevent the caterpillars from crawling through them.

One advantage of using gauze is that, should the butterflies or moths be allowed to emerge in the same cage, as suggested, their wings will not be damaged as they would be if they beat them against glass.

Tent-making caterpillars like those of the lackey moth (see figure 114, Part I) form excellent material for observations.

It is quite easy also to repeat the experiments made by Professor Poulton to show the power that caterpillars possess of turning into chrysalides of a colour which more or less agrees with the surroundings in which they have to pass their period of rest, or of modifying

the tint of their cocoons, in cases where these are made, in a similar way. One of the most striking instances is that of the caterpillars of the "tortoise shell," "peacock," and "red admiral" butterflies. Professor Poulton allowed the caterpillars to change in little compartments lined with white, green, and black paper, as well as with gold leaf. He obtained light, dark, and even quite golden chrysalides as a result.* We have found if caterpillars of the tortoise-shell butterfly are allowed to suspend themselves from white paper, and shortly afterwards the piece from which they are hanging is removed and fastened by means of a pin to a tiny cork previously stuck to the face of a looking-glass, very remarkable chrysalides, which are golden all over, may be obtained. Many other experiments that have recently been made, may be repeated, and others, of an original kind, be devised. Probably the larvae of other insects may be found to possess similar powers. Returning to caterpillars, those of a large hawk-moth like the privet hawk are handsome creatures which it is a pleasure to possess and to watch.

Photograph by Wilfred Mark Webb.

FIGURE 199.—A Lobster Caterpillar.

* "The Colours of Animals," pages 113-139. Kegan Paul & Co.

Indeed, we shall have something to say with regard to butterflies and moths from the aesthetic point of view in a moment. These

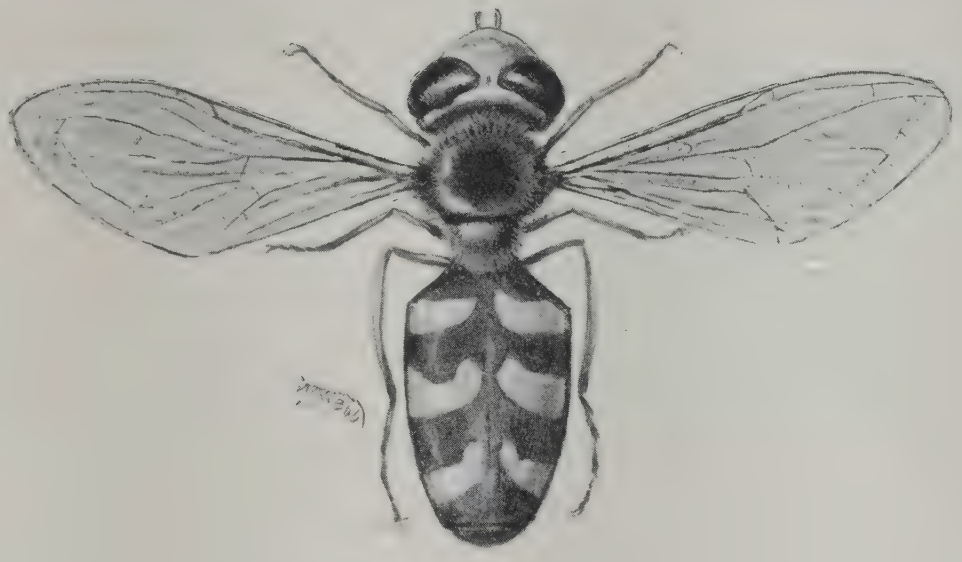


FIGURE 200.—A Hover-fly.

large caterpillars have their bodies generally green, but slashed with bands of more brilliant colour, so that the large expanse is broken (see

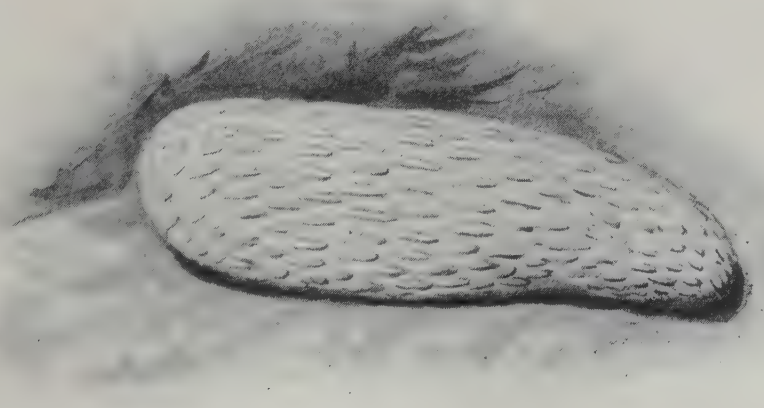


FIGURE 201.—The egg of the Hover-fly enlarged.

figure 198), which tends greatly to conceal them from their enemies so long as they remain among leaves. When, however, it

is time for them to descend to the ground to bury themselves, they lose their bright tints and harmonise more or less completely with the soil. There is one caterpillar which is of special interest, and has quite a number of methods of defence. It is that of the lobster moth (see figure 199). When hatched, its long legs and the swollen

FIGURE 202.—The larva of the Hover-fly preying on aphides.

end of its body taken in conjunction with its dark brown colour and peculiar movements, might easily cause it to be mistaken by its enemies for an ant, an insect which is usually left severely alone on account of the acid which it can eject. Other observers have noted further characteristics which the lobster caterpillar possesses. When it remains quiet, it looks for all the world like a piece of dried leaf. Should, however, the suspicions of a hungry bird be aroused, and it attempt to peck at the caterpillar, the latter starts into action, and by waving its long legs affects the appearance of some huge spider, and so scares away the bird. There are other enemies of more subtle character, to the attacks of which caterpillars are open; that is

to say, the ichneumon-flies, which lay their eggs inside the caterpillars, with the result that the grubs which hatch out so weaken their host that it has not strength to become a butterfly or moth, even if it is able to turn into a chrysalis. Where the body of the caterpillar is pierced, a mark remains, and upon that of the lobster caterpillar there is a spot naturally produced which will deceive the ichneumon-fly into believing that her prey has already suffered from the attentions of one of her kind, and she straightway departs leaving it unmolested. Other British caterpillars, such as those of the elephant-hawk moths and the puss moth, have peculiar devices which the young student may well discover for himself, and he may advantageously seek an explanation of the brilliant and conspicuous coloration of some caterpillars (and indeed of other animals), which instead of obscuring them, forces their presence upon one's notice. Beautiful as caterpillars may be, they are far surpassed by many butterflies, and one of us has suggested that they might be reared like flowers * very generally are, merely for their appearance. For the purpose of keeping, say, the beautiful swallow-tail butterfly, a large flight cage should be made of mosquito netting, preferably protected by a small glass-house built over the ground in which carrots (the food plant of the larvae) in a flowering condition are growing. If a large number of insects

Photograph by Alban W. Duffield.

FIGURE 203.—A white Butterfly.

* "A Caterpillar Farm." By Wilfred Mark Webb, F.L.S. *Royal Magazine*, Vol. VII (1902), page 531.

are kept, it will be necessary to feed them by putting honey on the flowers. The "Camberwell Beauty" is another form which may be successfully reared in confinement. In many cases it will be necessary to get a stock from a collector or dealer. There are, however, plenty of insects of similar or other kinds which may be obtained by the student himself.

In almost any pond or stream the larvae of the dragon-fly may be found. Even in a London back garden the interesting life history of the hover-fly may be completely watched. This insect looks like a small wasp, but has only two wings, and lays its eggs among the aphides which attack the more juicy plants of the garden. A little patience will enable the observer to see the actual deposition of the egg (see figure 201), which under a lens is rather a pretty object. The young grub in the course of a few days hatches out and begins to feed upon the aphides (see figure 202), destroying a prodigious number of these before it turns into a pupa and completes its life history (see figure 200).

It should be mentioned that a bag of muslin known as a "sleeve," which is placed over the part of a plant or the branch of a tree, obviates the necessity for "breeding cages" for many insects. The caterpillars or larvae can be placed in the sleeves and the open end tied securely round the branch. The leaves keep quite fresh until they are all eaten up, when the insects can be transferred with their covering to a new branch. In the same way the grubs of hover-flies, or other insects which feed on aphides, may be kept under observation.

The more advanced student may well turn his attention to the subject of cross-breeding butterflies and moths, upon which comparatively very little work has been done.

Photographs of Insects

It is hardly necessary to say that insects in all their stages offer excellent subjects for the nature photographer. It would be extremely hard to get a more beautiful or interesting picture than that which forms the frontispiece to Mr Richard Kearton's latest book.* The photograph alluded to shows two common white butterflies roosting on a head of nap-weed, and their bodies, antennae, as well as the florets of the head, are covered all over with tiny beadlets of dew.

Collections of Insects

We have elsewhere urged that the student who has a taste for collecting should choose some more obscure creatures than butterflies and moths, for if he does not, he will be liable to be condemned by many. Without going into the inconsistencies of so-called humanitarians, it may be well to point out that there is a reason for this. Butterflies, at any rate, are beautiful, and to destroy them unnecessarily means to deprive others of the pleasure of seeing them. By breeding insects and rearing their caterpillars himself, the collector can to some extent avoid lessening the already small number of many of the insects in question, and at the same time obtain quite perfect specimens for his cabinet.

* "Wild Nature's Ways." Cassell & Co. Price 10s. 6d.

OBSERVATIONAL LESSON XXVII

Part I—A Growing Potato

Preparations for Work

Distribute the potato plants.

Directions to the Pupil

(1) Remove some of the soil if necessary, and draw a "new" tuber showing how it is joined to the old plant.

Part II—A Snail

Preparations for Work

Common snails, well grown, and which have been recently wetted, and tubular lamp chimneys should be handed round.

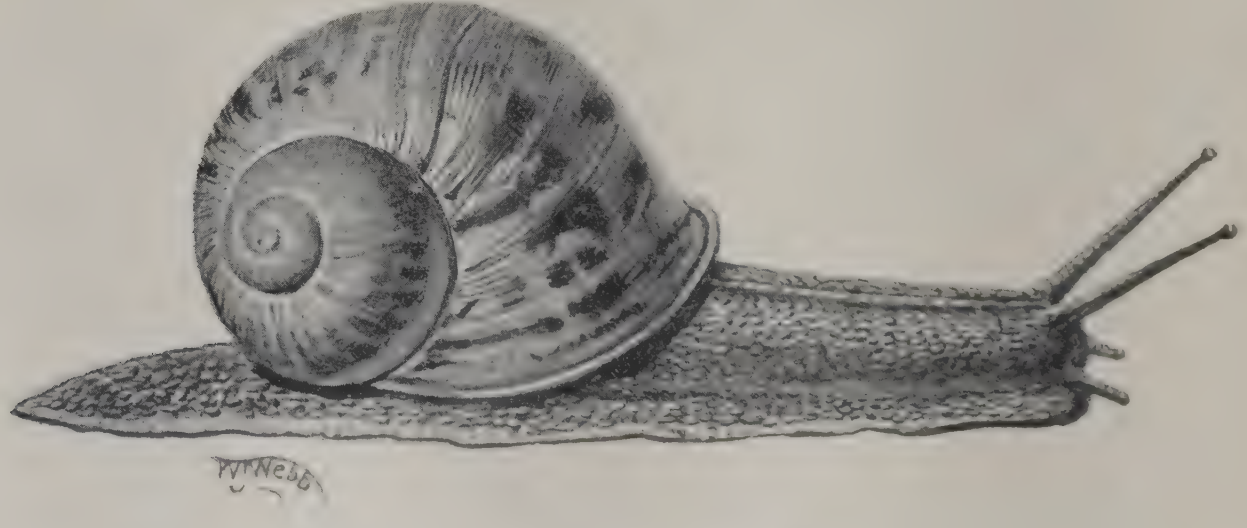


Figure 204.—The Common Snail.

Directions to the Pupil

(2) Allow your snail to crawl inside the glass tube. Write a description of the shell, mentioning its shape and colour. Make a careful drawing of the whole creature. Answer the questions, where are its eyes? Where is its mouth? Indicate their position on your sketch.

(3) Examine carefully the skin of the animal, and write down two special features of it.

(4) Gently touch one of the tentacles or "horns." What happens? Watch carefully the way in which the horn reappears.

(5) Turn the tube round and look at the underside of the animal. Describe how it moves from place to place. Make a sketch, and discover the large opening on the right side under the edge of the shell, through which the creature breathes.

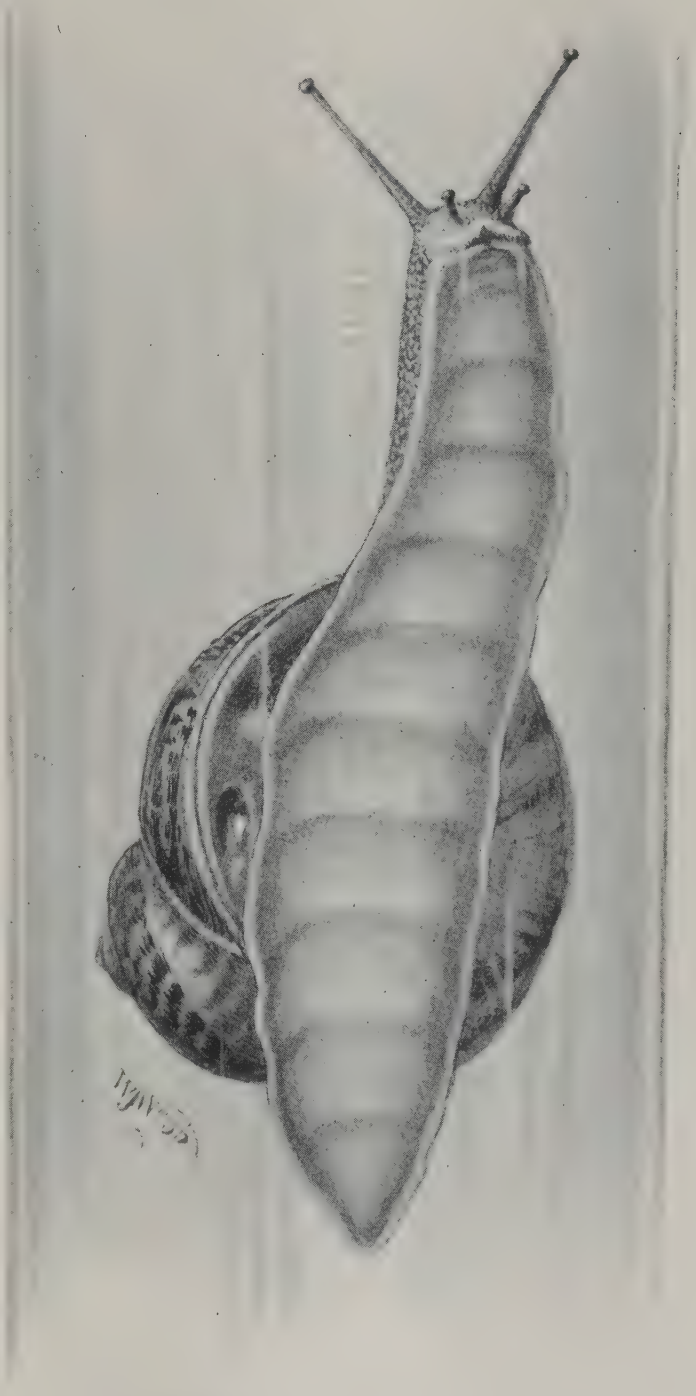


Figure 205.—The underside of a Snail.

Suggestions for Further Work in School

The way in which snails feed should be watched, and if a young specimen is held to the light, the movements of the organ which perforates the leaves when the creature feeds may be seen through the semi-transparent body. In thin-shelled examples, and in smaller species, it is possible also, on looking at the underside of the shell when the animal has retired within, to make out the beatings of the heart. It will not be amiss to have a few empty shells at hand, and the whorls of some should be broken away so that the spiral chamber can be followed.

CHAPTER XXIX

SLUGS—LAND AND POND SNAILS—COLLECTIONS OF SHELLS

Slugs

The snail which was considered in Lesson XXVII is so different from the majority of creatures ordinarily met with that it has an attraction for many, and its hard shell enables it to be handled without necessarily touching its moist body. Less attractive, though by no means less interesting, are the slugs. With few exceptions they have

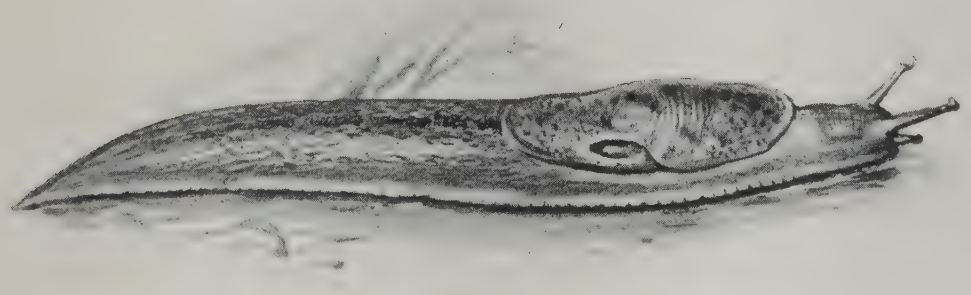


Figure 206.—The great Grey Slug.

lost, in course of time, the outside shell seen in the snail, but many have an internal shelly plate which is not developed in the latter. Apart from the changes in colour which many slugs seem to undergo during their lifetime, and with regard to which little work has been done, one of their most interesting features is their power of finding their way back to the spot which they have chosen as their home, after their nightly excursion, a fact which can be proved by an examina-

tion of the silvery trail they are accustomed to leave behind them. Another striking point with regard to slugs, is the way in which some of them can let themselves down from trees or other places by means of a thread of slime, which often may extend to several feet in length, and which is so tenacious that some times a slug can climb up it again.

FIGURE 207.—A worm-eating Slug.

Besides these shell-less and more familiar slugs, there are one or two in this country which live underground and feed on worms which they seize and swallow. The remarkable organ by means of which the snail rasps off its vegetable food, is in their case so enlarged that it can be protruded to some distance from the mouth, and the sharp spikes with which it is seen to be beset are (as can be easily proved under the microscope) strongly barbed at the point like a fish-hook.* An interesting series of observations may be made upon the worm-eating slugs, for by gently touching them with a paint brush they may be led to imagine that they are meeting a worm in its burrow, and induced to thrust out their "tongue." If a worm be allowed to crawl against the front of one of these slugs, it will very often endeavour

FIGURE 208.—The egg of a worm-eating Slug.

* See "The Manner of Feeding in Testacella scutulum." By Wilfred Mark Webb, F.L.S. *The Zoologist*, Series 3, Vol. XVII (August 1893), pages 281-289, Plate 1.

to find a way into the slug, with the result that it is caught by the "tongue" and devoured. The worm-eating slugs, which are often found in large numbers in gardens, may be recognised not only by their rough skins but also by the presence of a tiny shell, like a finger nail on a finger which is situated on the hinder end of their bodies (see figure 207).* The eggs of these creatures are comparatively *very* large and possessed of a hard shell.

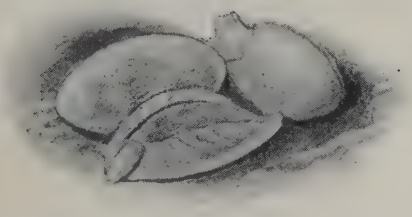


FIGURE 209.—A newly hatched worm-eating Slug.

LAND AND POND SNAILS

Besides the common snail, there are many others more or less related to it to be found in this country amongst grass, under stones, or in the open. We figured the large edible snail with its winter "lid" on page 108, Part I. There are also somewhat smaller and more gaily coloured snails; others again, so minute as to approach in size the proverbial pin's-head, while some very elegant forms with narrow pointed shells recalling marine forms are to be met with. Though these forms are fairly well known, as naturalists have long paid attention to them, there is much of interest about them. Here we find small snails which emit a strong odour of garlic; there, a form with distinct bristles on its shell, or one which plasters its home with mud in order to escape attention; while we know of some provided with a little shelly plate hinged inside the mouth

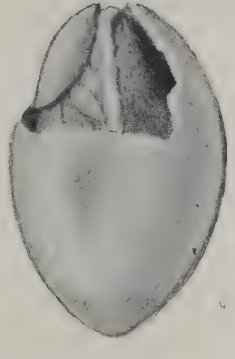


FIGURE 210. — The egg of a worm-eating Slug broken open to show the young one inside.

* The recent floods at Eton (February 1904) caused a great number of these slugs to come above ground in Mr Hill's garden. It was found that they could undergo several days' submersion without harm.

of the shell which it can completely close, so as to exclude any small intruders. One form we have, with a permanent lid on the end of its "tail" which, as in the case of the periwinkle, makes a perfect door when the animal retires to its shell. This creature dwells in chalky districts, and its method of crawling might well be compared with that of the common snail. Other forms of similar structure, but breathing water and already alluded to as fresh-water whelks (see Chapter XIX), are to be found in ponds and streams, where also many air-breathing snails of various forms abound.

In fresh water also will be discovered small bivalves shells, which we know as fresh-water cockles, some of the latter being not so big as a hemp seed.

Collections of Shells

All the shells of these creatures may be easily preserved, and when mounted in glass-topped boxes on cotton wool, produce a very pleasing effect. Boxes should be got, somewhat deeper than the largest shell which is to be admitted into the collection. Rough cotton wool may be put into the box so as to form a foundation. A piece of thin pliable cardboard can be cut so that it would easily drop into the box; round this a piece of fine jeweller's wadding* should be folded so as to leave the smooth surface uppermost, and the whole arrangement laid on the rough material, after which the edges of the fine wadding should be pushed inwards with a pair of forceps or scissors until it is perfectly even. On this the shells, if of fairly large size, are to be laid. Sometimes it is preferable when the shells are very minute

* See Appendix.

to arrange them on the glass of the lid, which is turned upside down for the purpose, afterwards placing the wool-covered card, and over them putting the lid on the box. If the shells are large, it may be well to cut holes in the card, so as to make hollows in which they can rest.

OBSERVATIONAL LESSON XXVIII

Spines and Prickles

Preparations for Work

Give to each pupil short branches of hawthorn, false acacia and gorse, together with a piece of wild rose stem and some holly leaves.

Directions to the Pupil

(1) Make a sketch of the thorn of hawthorn, and write beneath it the part of the plant that you think it is.

(2) Where do the spines grow in gorse? Indicate this on a sketch of a shoot. Examine the great spikes at the base of the leaf in the false acacia. Make a drawing.

(3) Try whether the prickles of the rose can be detached from the

Figure 211.—A spine of Hawthorn.

stem. Sketch them. When in the country, examine a rose tree growing through a hedge and see if you can find a second use for the prickles.

(4) Make a rough sketch of the holly leaf. Leave a space

FIGURE 212.—Spines of False Acacia.

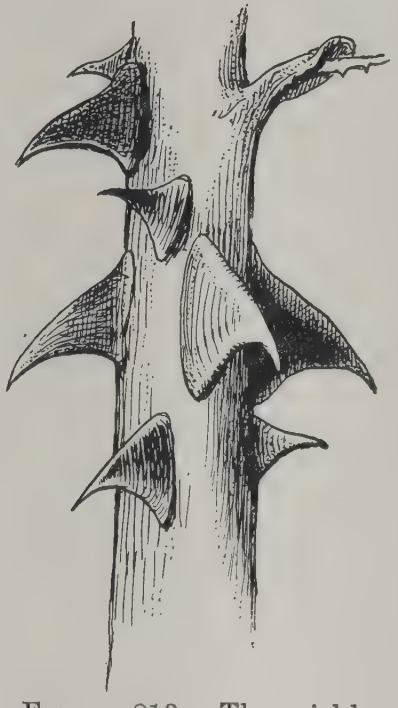


FIGURE 213.—The prickles of Wild Rose.

for a drawing of one taken from the topmost branch of a tree.

(5) Write the names of the plants one under the other, and add at the side a brief description of the points of the prickles which they bear.

Suggestions for Further Work

Endeavour to find other plants which are protected by spines and prickles formed of, or on, similar structures to those studied. These should be drawn or preserved. The examples which are alike should be put together and their similarity noted down.

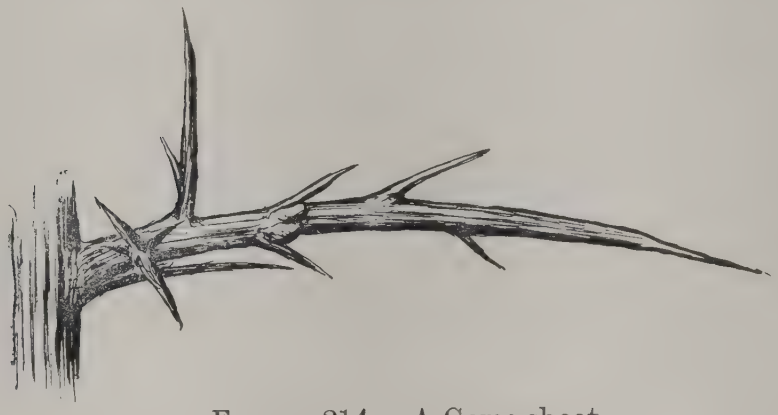


Figure 214.—A Gorse shoot.

Figure 215.—The leaf-like branch of "Butcher's Broom" bearing a flower bud.

Figure 216.—The fruit of "Butcher's Broom."

CHAPTER XXX

THE DEFENCE OF LEAVES AND STEMS—POISONS—SPINES AND PRICKLES —BRISTLES AND STINGING HAIRS —MEANS OF DEFENCE OF ROOTS—HOW PLANTS HEAL THEIR WOUNDS—TREES IN SUMMER

The Defence of Leaves and Stems

The keen struggle for existence which is going on daily and hourly in nature has brought about an almost infinite number of ways by which plants protect themselves against their enemies. Putting aside the tropics, where plants may be almost said to have passions, so keenly do they fight among themselves and against their animal foes, it is quite easy to find in almost any hedgerow instances of plants protecting themselves by special means. We would advise the nature student to collect and tabulate for himself as many kinds of these weapons as he can find. Plants also have to defend their stems and leaves against the attacks of grazing quadrupeds, and their roots from burrowing mammals and other depredators.

There can be no doubt that since the time when life first appeared on this earth, the vegetable and animal world have been more or less at war with one another, since all animal life must ultimately depend on vegetable, while plants are practically independent of animals, except in so far as they rely on them to ensure cross-

fertilisation. It is therefore of the greatest interest to the nature student to study the means by which some plants, at any rate do their best to, protect their leaves and stems, which are the parts most likely to be attacked.

The chief weapons of plants are (*a*) poisons, (*b*) prickles and spines, (*c*) stinging hairs.

We will give but one or two instances of each, and leave it to the student himself to determine from his own observations what parts of the plant are specially modified to form these defensive weapons.

Poisons

The deadly nightshade, severely left alone by all grazing animals, is nevertheless the food plant of one particular animal. What is it? Other poisonous plants are easily to be discovered and collected. It is obvious that a knowledge of poisonous plants that are to be found in pasture lands is of great importance to the farmer. One of us remembers having to award a prize to the best of a number of botanical essays. The prize was given for a description and collection of the poisonous plants from an English county.

The work had necessitated the reading of many quaint old books on herbs and simples,* and had evidently proved a labour of love to the competitor.

Spines and Prickles

The gorse, blackthorn, holly, and barberry are all familiar plants. In each one, however, the prickles are provided by different parts of

* An excellent book on the legends and superstitions attaching to plants is "Folklore of Plants," by Sir W. T. Thiselton-Dyer.

the plant. If the student make out a table for himself something like the following, he will be able to assign in each case the prickle to its particular origin.

INSTANCES OF PRICKLES FORMED BY:—			
Whole Leaves.	Parts of Leaves.	Ends of Branches.	Modified Hairs.

Bristles and Stinging Hairs

Many plants such as borage, comfrey, and nettle have peculiarly formed structures on their stems and leaves. A very little trouble and the use of a microscope will enable the student to find out the nature of the weapons of defence.

It is a matter of common knowledge that a nettle grasped by the stem and stroked from below does not sting, while any attempt to seize it from the top will result in the offender being stung. What is the cause of this? It is again often said that if a nettle is grasped strongly no pain will be felt. Is this so? If so, why?

Lastly, reference must be made to a non-British plant so common in our greenhouses, the cactus. Unless the student is a botanist, he will almost certainly fail at first sight to say what part of the plant

the prickles are, but a closer examination will reveal the secret. Again, let him find an answer to the question, "Why are desert plants so often prickly?"

Means of Defence of Roots

No doubt there are a great many plants that have not found it necessary to protect their roots in any special way, being successful enough in the struggle for existence without having to do so.

On the other hand, however, there are some exceptions, the soapwort for instance, the roots of which never seem to suffer from attack. They produce a bitter nauseous substance which renders them distasteful to most, if not all animals. The monk's-hood, again, has a highly poisonous root. Here perhaps for once the student will have to rely on book knowledge and hearsay, as actual experiment in this line would be difficult, not to say dangerous.

How Plants heal their Wounds

When a soft-stemmed plant is wounded, the place heals over, or to be more accurate, it is covered with a layer of cork. The raised letters which we sometimes see on large vegetable marrows or pumpkins advertising the name of the grower are made of cork, produced by scratching the required letters on the fruit when it is young. When seed potatoes are cut up for planting, it is not customary to set them at once, as it is advisable that the wounded surfaces should heal somewhat before being put into the moist ground. In woody plants such as trees, the process of healing is comparatively much slower. If a piece of bark is stripped from such a stem and the wood is laid bare, the living parts that form the annual rings immediately die, and there is nothing left which can

rapidly give rise to cork. Under the bark that forms the edges of the wound, the tissues remain that can make fresh cork and wood, and the mass of new material which they at once begin to produce, and which constitutes what is called the callus, creeps gradually over the exposed surface. Figure 217 shows a section of a stem that has been wounded on the side, and figure 218 represents the wound itself, in process of healing. When a wound is very large or in a particularly exposed position, the uncovered wood may rot before it is again protected, and the wound in consequence may never heal satisfactorily.

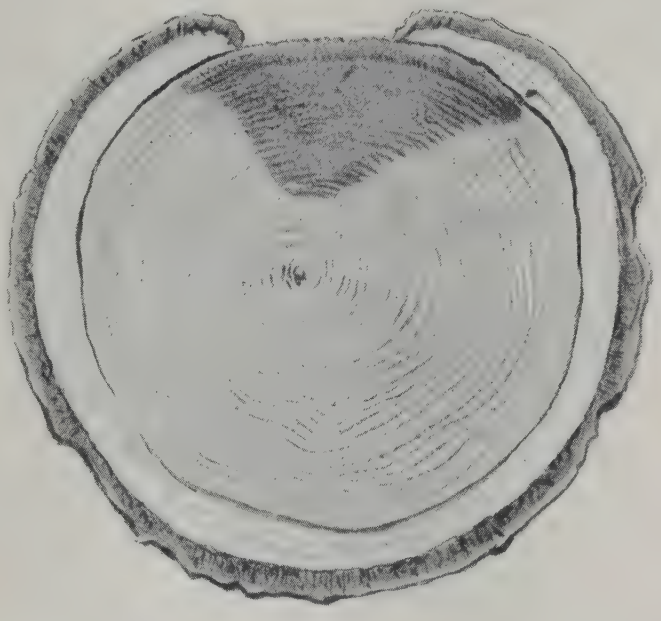


FIGURE 217.—A section across a side wound in an Ash branch. The shaded part indicates where the exposed wood has begun to rot.

If two wounded stems are held together sufficiently closely, and precautions taken to prevent drying or rotting, as well as to make the breadth and length of the wounds equal, so that the live parts coincide, the callus at the two edges of one stem will in certain cases unite with that of the other (see figure 219) which grows against it, and in the following year (see figure 220) the two stems will jointly form a new annual ring which will permanently hold them together. This is what is done in inarching and grafting, though in the

Photograph by Wilfred Mark Webb.

FIGURE 218.—Side wound on an Ash branch.

FIGURE 219. — A cross section of a recently made Apple graft. A satisfactory junction has been effected on the right-hand side. Note, that the scion is uppermost.

FIGURE 220. — A cross section through an Apple graft after a year's growth. A complete woody ring holds the woody portions of scion and stock (which never actually unite) together.

second case one of the component stems is removed to begin with from its own roots, and wax or clay placed round the junction to keep moisture in and rain out.

Trees in Summer

We may now remind the student to secure photographs in summer

Photographs by Reginald H. Weaver.

Figures 221 and 222.—A Maple Tree in Winter and in Summer.

dress of those trees which in the winter and early spring were taken in a leafless condition, or which will be, when they once more become bare. The object in view is the comparison of the same tree as it

appears in summer and in winter, by placing two pictures side by side which have been obtained in each season respectively. These should be taken from the same distance and the same place, the spots where the legs of the tripod rested in the first case being marked by pegs driven into the ground as before suggested (Part I, Chapter XIV).

It will not be found quite such an easy matter as may be imagined to discover trees which can be photographed quite free from their surroundings and in such a way that their whole outline is perfectly seen. A park especially where the lower branches of the trees have not been removed should be sought for. Some very good pictures have been obtained in Windsor Forest, while Kew Gardens will prove useful to the dweller in London, although the trees in the latter spot are planted so very closely together that some difficulty will be met with in making a choice of subjects.

OBSERVATIONAL LESSON XXIX

Part I—The Movements of Plants

Preparations for Work

Pots containing plants which produce tendrils, for instance, peas, bryony, and others of which the leaf stalks attach themselves to supports, such as canary creeper, should be on the table. Arrangements should also be made for the placing of thin rods, about a quarter of an inch in diameter, near young tendrils or leaf stalks so that the time which these take, to obtain a hold, can be noted.

Directions to the Pupil

(1) Take one of the small rods and push it into the earth of the pot, so that it comes into contact with the slightly curled tip of one of the tendrils growing upon one of the plants of pea or bryony.

Put your plant on one side for subsequent examination, after having noted in your book the time at which you placed the stick in position, and having made a sketch of the tendril.

(2) Treat the leaf stalk of canary creeper in the same way, and having made your drawing, examine the one already dealt with.

If there is little or no result, proceed to the other work outlined below, and at the end of the lesson make a second sketch of the tendril.

Part II—The Sun (*continued*)

An opportunity may be taken of making further records (see Lessons XVII and XXVI; see also Part I, pages 20 and 22).

Part III—A Goldfish

Preparations for Work

Give to each two students (at least) a small globe containing a living goldfish in water.

Directions to the Pupil

(3) Draw diagrams of the fish—
  (*a*) As it appears from the side.
  (*b*) Showing it, as looked upon from above.

(4) Write down the number of fins, and six other points concerning the fish, that you may observe.

Note:—Remember to complete the work of paragraphs 1 and 2.

Suggestions for Further Work in School

Some fresh fish in which the gills are not clogged together, might be handed round, so that the arrangement of the mouth and gills might be seen.

CHAPTER XXXI

CLIMBING PLANTS

BESIDES the simple experiments arranged for in the previous lesson, it is easy to carry out a series of observations * on climbing plants whereby much may be learned concerning their movements and the different methods which they adopt for the same purpose.

It is of course well known that various parts of the plant are used in different cases for climbing, and the student is recommended to make a table something after the following manner, and add to it from time to time as his knowledge of these plants increases. We have ourselves omitted to give instances.

CLIMBING PLANTS.

Part of the Plant which helps in Climbing.	Examples.
1. Stem.	
2. Roots.	
3. Leaf Stalks.	
4. Tendrils formed from leaves.	
5. Tendrils formed from stipules.	
6. Tendrils formed from— (*a*) Ordinary shoots. (*b*) Flower shoots.	

* The experiments sketched out are intended to point a way, and not to constitute one in themselves.

It is interesting to note the methods by which young climbing plants like the hop and French bean seek to find something to climb up. Place a young hop plant in a pot and do the same with a French bean (in the latter case it is best to sow the bean). When a shoot appears six or eight inches above the ground, its movements may be studied. It will be found that the stems turn in a circle. A complete revolution can easily be timed in these plants. In fact, the actual movement may be watched by placing a collar of white paper on the lower part of the shoot, when the shadow of the moving part will be seen passing across it. While this rotation is going on in the tip, another change will be taking place in the stem, which should not be overlooked, and the student should not fail to observe in which way the two plants twine respectively. Futhermore, he may devise for himself a way of showing that the direction of the twist is not accidental, and that the plant cannot be forced to twine in any other way. Again, the extent of surface that a shoot will explore should be ascertained, and the student should note what happens ultimately if the stem has nothing to climb upon.

Further, the pea, which climbs by means of tendrils, may be profitably studied. First, the movements which the tendril makes in searching for something to catch hold of, and then its actions on touching a solid body, will seem little short of marvellous. By tickling the tendrils with rods, it is easy to find at what age and in what part the tendrils are most sensitive ; how soon these begin to bend round the rod ; and how long they take to straighten again, if the rod be removed. It should be determined whether the tendril is more sensitive in the sunshine or in the shade ; in damp than in dry air. Again, let the student cover a rod with moist gelatine and note the behaviour of the tendril when it is brought into contact with it.

Finally, an interesting experiment is, to ascertain with what

strength, for instance, Ampelopsis which has tendrils provided with peculiar discs, maintains its hold.

Induce a shoot to grow on to a stone or some movable object.

Cut off the shoot from the plant, and by means of weights on a spring balance the force necessary to pull the tendrils from the stone can be ascertained, though as a matter of fact, it generally happens that the tendril is torn rather than the discs detached.

Again, the method of attachment of the ordinary Virginia creeper should be noted and cases examined in which the tendrils have not come into contact with a solid surface. The effect on the structure of the tendril is striking.

Photograph by Wilfred Mark Webb

FIGURE 223.—A Bryony Tendril.

OBSERVATIONAL LESSON XXX

Part I—The Movements of Plants (*continued, 2nd Investigation*)

Figure 224.—A Sundew leaf.

Preparations for Work

The same plants that were used in the previous lesson to show movements on the part of tendrils and leaf stalks should be put ready. Sundew plants growing in small pots with "sphagnum moss" will also be wanted.

Directions to the Pupil

(1) Take a very minute piece of raw meat and place it in the centre of a well-grown leaf of the sundew plant.

Figure 225.—A Sundew leaf feeding.

(2) Make a sketch of the leaf, and note down any points about it in which it differs from the leaves of other plants.

(3) Put the sundew on one side, and sketch the tendril

which you examined and drew, last week, on the pea or bryony plant.

(4) Repeat the operation with regard to the leaf stalk of canary creeper.

Examine the sundew. If the leaf is little changed in appearance, put off drawing it until after you have carried out the instructions given in Part II.

Part II—A Dove

Preparations for Work

Living specimens of the ordinary domesticated ring-dove, in cages, will be necessary.

Directions for the Pupil

(5) Write down one below the other, on the left-hand side of the page in your note-book, the words dove, hedgehog, horse, snake, frog, goldfish ; and, in a second column to the right of them, briefly describe the outer coverings of the various animals.

(6) Mention any structures which you notice that the pigeon possesses which you have not seen in any other of the creatures that you have studied.

Note :—Complete your work upon the sundew leaf.

CHAPTER XXXII

PLANT CONSTRUCTION

In this chapter it is not our intention to discuss the minute study of the plant body with the help of a microscope, which is necessarily a branch of indoor work. We would rather suggest what can be done in the field, with sharp eyes and the occasional use of a pocket-knife. It is perfectly obvious that the precautions which engineers take in building pillars, in supporting weights on brackets, and so forth, must be likewise taken when a huge trunk grows upward to the sky, and weighty branches with their thousands of leaves spring out in all directions from its sides. The nature student should notice how the heaviest part of a tree stem is at its base, and how the roots very often form buttresses and so give it stability. By growing large varieties of Indian corn, a similar use can be seen in the case of the roots which are pushed out from the lowermost joints of the stem as the plant increases in height and the swollen heads of fruit grow heavier.

It would be interesting to examine the junctions of branches with the main stem by cutting down to the pith. In those plants where the latter is comparatively wide, as in Figure 226, it will be found that a band of wood cuts off one cavity from another and so gives strength to what would otherwise be a weak spot. In the case of branches such as those of the apple, where the pith cavity is exceedingly small, there is a continuous passage from stem to branch.*

* Our attention was called to this interesting point by Mr John Gibbs, the Essex botanist.

There are also some interesting problems to work out with regard to the peculiarities of branching to be seen not only in trees, where those in certain positions seem always to take the lead, as well as in herbaceous plants which sometimes, as in deadly nightshade, would encourage one to believe that the main stem has divided suddenly into several parts.

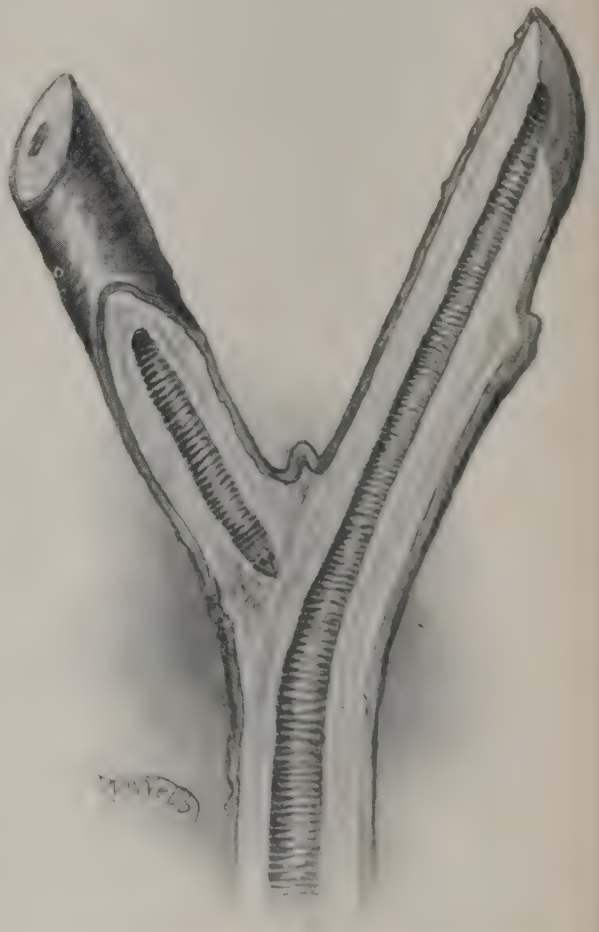


FIGURE 226.—A section showing how a side branch of Walnut joins another.

It is not possible to treat this aspect of plant life at all fully, but one other point may be raised. This is in connection with the water supply of plants. The leaves of those which have tap roots are so arranged as to shoot the rain to the base of the stem, whereas others which have spreading roots possess leaves which allow the rain to run off their tips. It is a common practice to shelter under a tree from the rain, as the foliage keeps a certain area beneath it more or less dry. It would be found upon investigation that just outside this the water accumulates, and there below the soil are the youngest and most active roots.*

* For many hints in this and other directions, the more advanced student may be referred to the "Natural History of Plants," by Kerner and Oliver, of which Messrs Blackie & Son are now publishing a cheap edition in eighteenpenny parts.

OBSERVATIONAL LESSON XXXI

Part I—The Movements of Plants (*continued, 3rd Investigation*)

Preparations for Work

Distribute the small pots containing sundew plants.

Directions to the Pupil

(1) What change has taken place in the appearance of the sundew leaf which you fed in the last lesson?

Part II—The Sun (*continued*)

Should an opportunity arise, make a further record as to the position of the sun. Mark the window and floor accordingly. (See Part I, pages 20 and 22, and Part II, Lessons XVII, XXVI and XXIX.)

Note:—This observation should be repeated at short intervals whenever the sun can be seen.

Part III—A Gall

Preparations for Work

Some fresh oak twigs bearing the common "marble gall" should be obtained and distributed. It would be well to have a few extra specimens.

Directions to the Pupil

(2) Make headings as usual, and fill in details as to the colour, shape, and size of the gall, which you see growing from the oak twig. Sketch it, and leave a space for a finished drawing.

(3) Examine the specimen further. Has it a skin? Of what sort of substance is it within?

Figure 227.—A Marble Gall showing the holes through which the insect inhabitants have escaped.

Figure 228.—A Marble Gall cut through, showing the cavities occupied by the grub.

(4) Split the gall through the middle and draw what you see. Discover, if possible, the grub (that hatched from the egg by laying which the parent insect caused the oak to produce the gall, in the first place).

(5) Describe the grub and others that may have sprung from the eggs of different insects which take advantage of the food and shelter afforded by the gall.

Suggestions for Further Work in School

Keep one or two galls singly in small wide-mouthed bottles, which are fitted with corks.* The insects which will issue from each gall in the future, may then be noted and examined.

Part IV—The Silkworm (*continued, 3rd Investigation*)

Preparation for Work

If by this time some of the silkworms have begun to "spin" (which they should do about this time in small paper cones provided for the purpose), specimens should be distributed in their papers.

Directions to the Pupil

(6) Make a careful note as to the way in which the silkworm caterpillar makes its cocoon.

Note:—If the caterpillars are still feeding, this work must be postponed.

* See Appendix, under the heading of Chapter XXIV.

CHAPTER XXXIII

THE STUDY OF GALLS—FAIRY FLIES

The Study of Galls

An excellent opportunity of studying the relationships between certain insects and particular plants is given by galls. In the lesson which has gone before, the common marble gall has been examined, and it has been suggested that the insects which form or inhabit it should be collected by keeping specimens in small wide-mouthed bottles. There are, however, very many other structures produced by plants owing to the activity of similar insects and also of mites and two-winged flies. Leaving the latter on one side, we might point out that the oak tree from which the common gall is obtained, is extremely subject to this and to a large number of others. Its leaves, buds, roots, and even flowers, respond to the attacks of various four-winged insects. Several kinds of galls which from their shape have been likened to silk buttons and to coins, or which are

Figure 229.—A Marble Gall-fly.

FIGURE 230.—A "Lodger" from a marble gall.

simply spherical, occur on the undersides of oak leaves. The artichoke gall is derived from a bud and the oak-apple also, though the insect connected with the latter differs in alternate generations, and one form produces the root gall of the oak. As an instance we might mention the sheep's-wool gall formed on the young male flowers of the oak (see figure 231). All sorts of problems will present themselves to the students of galls. Males of some of the insects have never yet been found; some forms can only be distinguished by the galls which are the result of their exertions; and the questions of "lodgers" and parasitic forms offer a large field for investigation. Turning to other plants, the red "robin's cushion" of the rose is familiar, and there are galls on the sallow, blackberry, and a host of other plants which make up an interesting series. The most satisfactory method of preserving galls in order to make a collection, is to dry the twigs which bear them in sand or some other material in accordance with the

FIGURE 231.—Sheep's-wool Galls on oak flowers.

directions given in Chapter XXV, and then to mount them on cards which are kept in glass-topped boxes.

FIGURE 232.—A "Robin's Cushion" on a rose shoot.

After the galls mentioned have been considered, in conjunction with them the excrescences caused by mites and two-winged flies

can be examined. Furthermore, there are the results of the activity of parasitic fungi as evidenced by "witches' brooms" and so on.

Fairy Flies

There is one family of insects of very great beauty and interest, but of exceedingly small size, which need the microscope for examination, though they can just be distinguished with the naked eye. Their larva passes its life, it is believed, in the eggs of larger insects, and the adults have hitherto been found on window panes, the transparency of which enables the tiny bodies of the insects to be distinguished. The only apparatus required for collecting these creatures, which appear in the summer, is a small tube of spirit and a paint-brush.

From a drawing by Frederick Enoch, F.L.S., F.E.S.

Figure 233.—A Fairy Fly.

These insects would well repay attention, though it would be difficult to work out their life histories without a great deal of experimenting in the hope of discovering the particular insect eggs in which each kind of fairy fly passes its early stages. There are very few workers at the subject; Mr Frederick Enoch, the well-known naturalist, is one, and Mr J. W. Gooch of Windsor is another who has discovered new species, but few if any others have turned their attention to the matter.

OBSERVATIONAL LESSON XXXII

A Piece of Turf

Preparations for Work

A piece of rough turf six or more inches square, according to the amount of vegetation represented, should be given to each of the pupils. It would be advisable if each student were also furnished with a wooden tray with raised edges, so that the rubbish may be kept within bounds. Sheets of white paper on which to lay the various kinds of plants discovered, and small glass-topped boxes or pots to contain any living animals that may be chanced upon, should be at hand.

Directions to the Pupil

(1) Very carefully break up the piece of turf, bit by bit, and place together on sheets of paper all the examples of the various kinds of plants which you discover. Make a note of the number in each pile when you have finished, with the exception possibly of the grass, and mention any of them that are in flower. Be sure not to overlook any of the simpler forms such as mosses or moulds.

(2) Collect as you go on any animals that you may come across. Make a list of them, draw those carefully of which you do not know the names, and label the sketches, when opportunity offers.

(3) Describe any peculiarities of the plants that you may think

help them to live together, or any ways in which one manages to get the better of another.

Suggestions for Further Work out of School

The inhabitants of a square foot of ground in various situations may with advantage be studied out of doors, and the plants tabulated that grow under the trees in the various kinds of woods alluded to in the next chapter.

CHAPTER XXXIV

PLANT ASSOCIATIONS

The late Robert Smith was one of the first in this country to recognise that the study of plants in the field should be something else than the mere "determination of their names and their places in the system of classification." While fully acknowledging the value of the latter work, he felt that it could be as well done in a garden or even with a well mounted herbarium, where an abundance of plants is brought together for comparison. In a paper* which was in type at the time of his death, he dealt with what we may call the out-door nature-study side of the question, and gave an account of his methods in the hope that they might be applied more widely in the early education of children. Throughout this book we have suggested the point of view from which plants should be approached in nature-study, and we are here interested more particularly in plant associations. The following quotation from the paper already alluded to may be given :—

"From the outset of the study, plants in nature are to be distinguished from those in a 'tidy' garden, which have been planted quite apart from each other, and often without regard to their natural requirements. In nature, plants are as a rule closely packed together, sometimes dependent upon one another, but more often competing

* "Home Lore : Plant Associations and their Distribution." *The Journal of School Geography*, October 1900, pages 287-295.

keenly for position, light, food and moisture. From this mode of life it follows that species with similar requirements will tend to grow together, and thus communities of species are formed, such as exists, for example, on the sand dunes or moors, or in the woods, marshes, or lakes. These plant communities or associations can be regarded as parcelling out the whole country between them, each variety being developed where the conditions of life are most suitable. In these associations the species are not arranged anyhow. A definite order can usually be distinguished, which is approximately constant wherever the particular association occurs. Examine a wood, for example, in Britain, and it will be found that, as a rule, only one or two species of tree predominate—almost invariably beech, oak, Scots pine, or birch. Competing with the dominant tree are others which only await the opportunity, in the form of some change of conditions, to supersede it and in their turn, predominate. With these, again, are other trees, such as the ash, which are always more or less solitary and secondary in an association. In the shade under the trees a subordinate vegetation is developed which is quite characteristic for each type of woodland, and which varies according to the amount of light, humus, or moisture. This subordinate vegetation has likewise its dominant, secondary, and solitary species. Thus each association presents a definite hierarchy of forms."

"The method of study here suggested is, in practice, a survey by means of a series of excursions, of the characteristic plant associations of the region. In Britain almost any district, however circumscribed, will give a wide range of vegetation, especially in those parts where hills are near the sea."

Robert Smith also pointed out the bearing which this work has on the teaching of school geography, which should rightly begin with the study of the home district and apply "the knowledge acquired

from actual experience to the consideration of ever-widening areas of the earth's surface." He continues :—

"The vegetation is an important element in the aspect of the home district. It gives the landscape its characteristic colour and its varying seasonal aspect. It is indicative of the climatic and soil conditions, and determines the leading productions and occupations.

Photograph by Francis J. Lewis.

FIGURE 234.—Succession of Moorland Vegetation on Redbourne Edge, Weardale.

The cotton-grass bog on the summit plateau changes to heather moor as the drier "edge" is reached, and the mat-grass heath (seen as light bands) which covers the steep slope of peat gives way to grass heath with cotton-grass below.

Thus it becomes one of the most important terms of comparison between one country and another."

It is possible to make a landscape in Britain serve as an example from which to picture the aspect of much of Europe, and the very

useful way of co-relating nature-study with geography would be to follow up this idea in detail.

Photograph by Henry Irving.

FIGURE 235.—Wild Hyacinths.

Dr William G. Smith has continued in Yorkshire, the scientific botanical survey of the vegetation which his brother, the late Robert

Smith, began so well in Scotland. His papers are, however, so far geographical as to find a place in the *Journal of the Royal Geographical Society.** They are illustrated in colours indicating the following types :—

Moorland : Pure Types

Bilberry Summit : *Bilberry dominant.*
Cotton Grass Bog : *Cotton Grass dominant.*
Heath or Heather Moor : *Heather dominant.*
Grass Heath : *Grasses, heath plants subordinate.*
Natural Pasture : *Grasses, no heath plants.*
Lowland Swamps.

Moorland : Transition Types

Cotton Grass, *with Bilberry.*
Cotton Grass, *with Heather.*
Grass Heath, *with Cotton Grass.*
Grass Heath, *with Heather.*

Woodland

Scots Pine and Larch.
Oak.
Beech, Oak, etc., *mixed* (*also* Parklands).

* "The Geographical Distribution of Vegetation in Yorkshire. Part I by Dr William G. Smith, and C. E. Moss, B.Sc., *The Geographical Journal*, April 1903; Part II by Dr William G. Smith, and W. Munn Rankin, B.Sc., *The Geographical Journal*, August 1903. Messrs W. B. Crump and C. Crossland have also discussed plant distribution and associations in the introduction to "The Flora of the Parish of Halifax" (to be obtained from W. B. Crump, Esq., 39 Akeds Road, Halifax, price 10s. 6d.).

FARMLAND

Cultivation, *with Wheat.*
Upland Cultivation, *without Wheat.*
Upland Cultivation, *with occasional Wheat.*

One point of great interest is the effect that one plant may have on others, as indicated by the effects of a beech-wood, for instance, on the undergrowth.

Since the above was written, Mr Francis J. Lewis, to whom we are indebted for one of our illustrations, has published some further contributions* towards the study of plant distribution in this country.

* *The Geographical Journal*, May 1904.

OBSERVATIONAL LESSON XXXIII

Part I—A Fern

Preparations for Work

Specimens of the common "male fern," from the roots of which the earth has been carefully washed, and which have been allowed to dry somewhat, should be given to each student.

Directions to the Pupil

(1) Make a sketch of the plant, and label the leaves, leaf stalk, stem, and root.

(2) Answer the following questions :—

Can you think of any way in which the fern resembles the potato tuber?

How are the leaves rolled up in the bud?

(3) Carefully draw a piece of a frond as seen from below, to show the coverings which protect the spore-cases. Supposing you had a dock

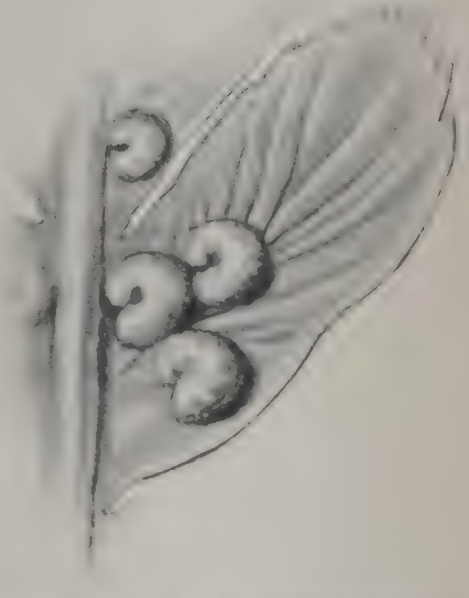


Figure 236.—Spore-capsule covers of the Male Fern.

leaf (a piece of paper will do instead), how many times would you have to cut into it, in order to make one of the little lobes which you have been sketching in the fern ?

Part II—A Silkworm (*continued, 4th Investigation*)

Preparations for Work

Give each pupil a silkworm cocoon.

Figure 237.—A Silkworm Chrysalis.

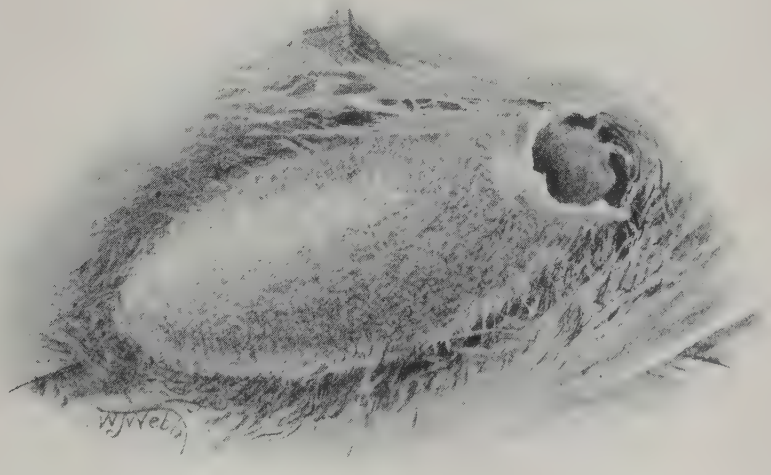


Figure 238.—A Silkworm Cocoon from which the moth has emerged.

Directions to the Pupil

(4) Make a sketch of the cocoon of the silkworm, and leave a space for a finished drawing.

(5) Carefully slit open the cocoon and gently remove the chrysalis. Is there anything in the cocoon besides this ? Write down

three features of the chrysalis which strike you, and say in what ways it differs from and resembles the caterpillar.

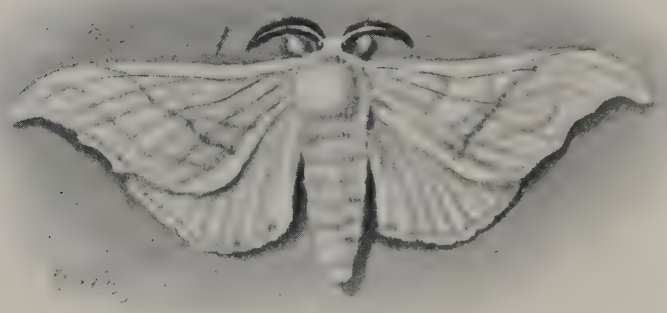


FIGURE 239.—A Male Silkworm Moth.

Note :—The moths will emerge from the chrysalides during the summer holidays. The way in which one end of the cocoon is opened should be discovered. Sketches should be made of the male and female insect, and eggs collected for next season.

FIGURE 240.—A Female Silkworm Moth.

CHAPTER XXXV

Plants that have no Flowers

LICHENS—MOSSES—FERNS

Lichens

If we could look back into the distant past history of our earth, and picture to ourselves the vegetation that clothed the dry land at the time when what we now dig up as coal was green and alive, we should be struck by the absence of flowering plants. In the place of trees, shrubs, and herbs which now cover our country side, we know that mosses and ferns existed, and rush-like plants, many of them vastly larger than their present day descendants. In fact, the science of geology teaches us that flowering plants did not appear until long afterwards. They are now the dominant group in nearly all parts of the earth's surface, except at high altitudes, but it seems not improbable that if, as astronomers tell us, our earth will one day be like the moon, its vegetation will once more, before life becomes extinct, consist solely of the flowerless plants.

Of these, perhaps, none are more interesting than the lichens, not only because of their double nature, but because they are essentially the vegetation of rocky and stony ground. Let us imagine a volcano which has recently erupted and thrown up a vast mass of liquid lava to the surface. This not only happens nowadays, but doubtless was far more widespread in former ages.

Even in our own islands there are several districts of which the surface rocks consist of nothing but vast sheets of cooled lava, erupted at a comparatively recent epoch. No one who ascends an active volcano such as Vesuvius will fail to be struck by the waste of black rock with which the mountain slopes are clothed. Nothing, it might be thought, could grow on such a barren-looking surface. Yet sooner or later the black basalt will be found to give way to a dull grey rock which, if more closely examined, will be seen to be stained a variety of colours. This appearance is produced by an encrusting lichen which marks, if we omit bacteria, the first vanguard of the vegetable world in attacking the newly formed rock. These lichens are next followed by mosses, which still further decompose the rock, turning lifeless inorganic substance into living tissue. Soon sufficient amount of soil is accumulated to give other plants, ferns, and grasses a hold; and seeds are brought by the wind and the other agencies alluded to in Chapter I, Part I, until little by little the barren waste of lava becomes a fertile and smiling landscape.

It is obvious, therefore, that lichens are among the hardiest of living plants. They can exist and flourish clinging to bare rock, such as on a mountain top is exposed to the most trying changes of weather. At one time scorched by the sun, at another drenched by the rain, and dried again by furious winds, these lowly plants, nevertheless, flourish in places where no other vegetation could even obtain a foothold.

What then can be the nature of the lichen?

With a strong hand-lens the student will probably be able to see from the cut edge that the lichen is a combination. Two distinct plants, a fungus and an alga are living together, and form a complex which can live in places where it would be quite impossible

for either to exist at all by itself. It is possible to grow each separately, but only in artificial conditions. How, then, it may be asked, do the algae and fungi meet one another? Are not the chances against the spores of the alga meeting with those of the fungi very great. It must be realised, however, that the algae, which help to form the lichens, are not the long green threads which occupy our pools and ponds, but minute green bodies of very minute size, which are only noticed in places where their myriad numbers attract attention, such as the green on old palings and bark of trees. These can dry up without harm and form a powder which can be blown great distances by winds of moderate strength. As to the fungus, everybody knows that the spores of various kinds are everywhere present in the air; otherwise, how do moist surfaces so soon become "mouldy." If the nature student wishes to convince himself of the fact that the spores of both algae and fungi are present in the air, it is not difficult to do so. In many places, but especially in mountain valleys, evidence may soon be procured. Nail a sheet of coarse filter paper to a board, keep it moist, and expose it for a few hours when a moderate wind is blowing. The microscope will show that sticking to the paper are the spores of many algae, mosses, and fungi, together with particles of dust and the pollen grains of flowering plants. In the same way these spores come to rest in grooves and irregularities on the surface of rocks and soon germinate, the algae spores into little cell groups, and the fungus spores into interlacing masses of threads; the former are embraced by the latter and the confederacy produced which we call a lichen.

The collection and identification of lichens will not be an easy task, but some of the common kinds should be examined by the nature student, to whom for further points in this remarkable group

we may refer to the chapter on lichens in Mr Scott Elliott's suggestive book.*

Mosses

Mosses are almost as widespread as lichens. Stone walls, the bases and trunks of trees, even the surface of the ground in woods, and especially peat are the chief habitat of these plants. Some kinds are found almost anywhere; others so fastidious that they are only met with in restricted areas. A study of mosses, like that of lichens, will need some botanical knowledge on the part of the student, but there are many points in their natural history which will appeal to all nature lovers. For instance, the soft little pieces of tuft moss that cling to old walls and weather-beaten boulders may be looked upon as living dust catchers. Pull off such as tuft and shake out the under surface on to a piece of paper. The amount of earth that is entangled in the fine "rootlets" is astonishing. Part of this is actual dust caught from the air, the rest the older and dead

FIGURE 241.—A Moss showing capsules.

* "Nature-Studies." By F. G. Scott Elliott. Blackie & Son, Ltd. Price 3s. 6d.

parts of the moss. These little cushions become fine nurseries for many different kinds of seeds, brought by the wind and entangled among the "leaves" and "stems." In some cases the plants arising from these seeds actually crowd out and destroy the moss, forming

Photograph by Wilfred Mark Webb.

FIGURE 242.—Liver-wort.

ultimately a bed of flowering plants. An interesting study therefore is to sow the scrapings from a tuft of moss in leaf mould specially prepared so as to have no seeds in it, and see how many different plants will grow from it.

Then, again, peat moss (sphagnum) is in some places so plentiful

as to be the chief form of vegetation, and is practically the only moss which has any economic value.

Mosses, like many other low forms of life, can undergo prolonged drying up without harm. The student may be recommended to prove for himself this fact with different kinds of moss, and especially note the condition and position of the leaves in the wet and dry state.

The allied liver-worts (see figure 242) might also be studied.

Ferns

Ferns are perhaps the best known of all flowerless plants, usually hiding away in moist and shady places as if they realised that their day was done and that they could never revive the ancient glories

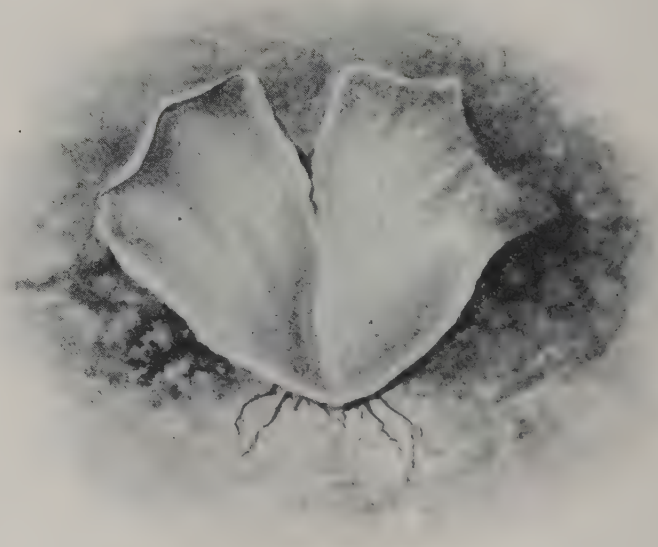


Figure 243.—A Fern prothallus.

of the carboniferous epoch when, as has been pointed out, they and their allies were the dominant group in the vegetable world.

Fern hunting is a delightful pastime, since it takes us into the

society of large and shady trees, cool streams with overhanging banks, the mouths of rocky caverns, and deep-cut lanes, often haunted by the rarer birds and mammals. Some ferns, however, prefer an open place to live in, such as the bracken, which sometimes covers many square miles of country; but this is exceptional, and the student will not have to think very long before the explanation of why most ferns love shade will occur.

Then, again, hunting for prothalli, the little heart-shaped plants to which the fern spores give rise, and which will bear the eggs of the new generation, is no easy matter. The plant is usually but a fraction of an inch in length, and requires some looking for. We have found prothalli in the decaying wood of old tree stumps, and well remember the triumph when a prothallus, hitherto only known to us from books, was discovered for the first time. The growth of young fern leaves is always interesting to watch, as they unroll in the spring from the dead-looking clump, and one notes the long red hairs which drop off later. What is their function? At present we do not know. If ferns are insignificant nowadays, they were of the greatest importance in earlier ages. It is difficult to realise that the vast amount of energy given out in the form of heat by burning coal by which, when used in steam engines, such an enormous amount of work is done, is really the energy of the sunlight which caused the ferns to grow countless ages ago, yet such is really the case. It brings irresistibly to the mind the story in the "Arabian Nights" of the genie who was for thousands of years bottled up in the vase which the fisherman drew to the shore in his net, and when set free grew to huge proportions; a fairy tale which is exactly paralleled by the story of the coal forests. We will conclude by quoting from Mr Scott Elliott's description of a Coal Measure landscape: "The atmosphere was saturated with moisture, and the

land covered with swamps of deep mud or ooze, interrupted by stretches of water full of the creeping rhizomes of living plants and of decaying vegetation. The temperature was higher than it is in the tropical forests of to-day, and the continual mists produced a dim shady light such as that found nowadays in the places most frequented by ferns. In such a warm steamy atmosphere both growth and decay were exceedingly rapid. Through forest swamps of this kind there meandered rivers which deposited in their basins masses of vegetable pulp mixed with silt. These beds have been transformed in course of time into cannel coal. In what is now the Welsh basin, heat or pressure, or both, fused the coaly matter and turned it into the hard, shiny, formless condition now called anthracite, which is the best steam coal for naval purposes."

CHAPTER XXXVI

Work for the Summer Holidays

LIFE HISTORIES OF INSECTS—NATURE-STUDY PHOTOGRAPHS—RELICS OF EARLY MAN

Life Histories of Insects

The long summer holidays will give an opportunity for the continuance of almost all the lines of work which have been suggested in the Second Part of the book. Many life histories of insects may be watched to their completion and others be begun. We will not do more than suggest a beetle, in the shape of the lady-bird, which can be watched even in a town. This, like the hover-fly, feeds on aphides, and so also does the larva of the lovely lace-wing fly.

In the summer the orange-coloured eggs of the lady-bird (see figure 244) may be found, for instance, on the under-sides of leaves in the garden. They are not raised on long stalks as are those of the lace-wing fly, nor do they lie on their sides like those of the hover-fly.

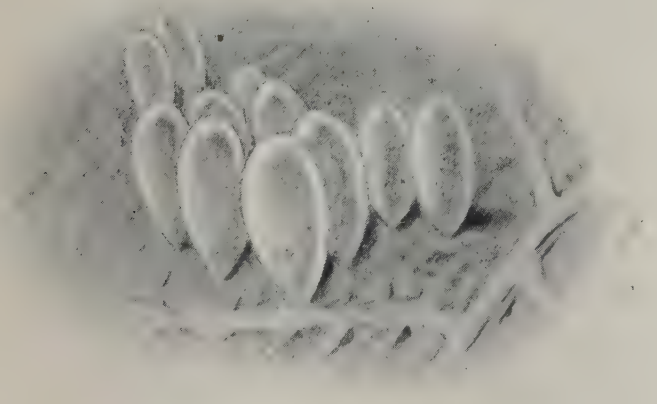


Figure 244.—The eggs of a twin-spot Lady-bird on the under-side of a hollyhock leaf.

From the lady-bird's egg there hatches out a lively little creature which, in spite of its six legs, has

FIGURE 245.—The larva of a Lady-bird.

considerable resemblance to the tiny crocodile (see figure 245). After consuming a large number of aphides or green-flies, and changing its coat several times to keep pace with its growth, the larva attaches itself to a leaf and once more shuffles off its skin. Now a pupa, it has a peculiar rough appearance, and on being disturbed, raises the free end of its body (see figure 246) several times in quick succession, apparently with the idea of frightening its enemy away. From the pupa, the adult lady-bird in course of time is produced (see figure 247).

FIGURE 246.—The pupae of a Lady-bird. The example on the right-hand side shows the position occupied by the pupa when disturbed.

In studying life histories, drawings and, where possible, photographs, should in all cases be made, and careful notes as well. The evenings may be spent by the lover of insects in

sugaring trees and obtaining specimens of night-flying forms. Others who have different tastes may mount their captures as suggested in Chapters XII, XXIII, and XXIX.

Cases illustrating complete life-histories of various species, particularly those of economic importance, that is to say, the friends and

FIGURE 247.—A twin-spot Lady-bird.

enemies of man, should be prepared ; and by those who do not make systematic collections, series, showing protective coloration and so forth, should be arranged. We should not overlook the fact that some students may be able to make models of larvae, for instance, which it is not easy to preserve in a natural or pleasing condition.

NATURE-STUDY PHOTOGRAPHS

Additions may be made to the photographs already taken of birds and their nests. Not only should a pretty picture be

Photograph by E. F. Winser.

FIGURE 248.—A Wild Duck's nest covered.

Photograph by E. F. Winser.

FIGURE 249.—A Wild Duck's nest uncovered.

Photograph by E. F. Winser.

FIGURE 250.—A nearer view showing the eggs.

These three photographs illustrate not only a Wild Duck's nest, but also the interesting way in which it is hidden by the old bird before leaving it.

Photograph by F. Graveley.

FIGURE 251.— A Black-headed Gull's nest and eggs.

Photograph by F. Graveley.

FIGURE 252.—Black-headed Gull's eggs hatching

obtained, but one which records some habit of the creature or episode in its life which is of value. We have all along emphasised also, the importance of continued observations, and our illustrations show in connection with birds' nests the work of two boys: one of these

Photograph by Alban W. Duffield.

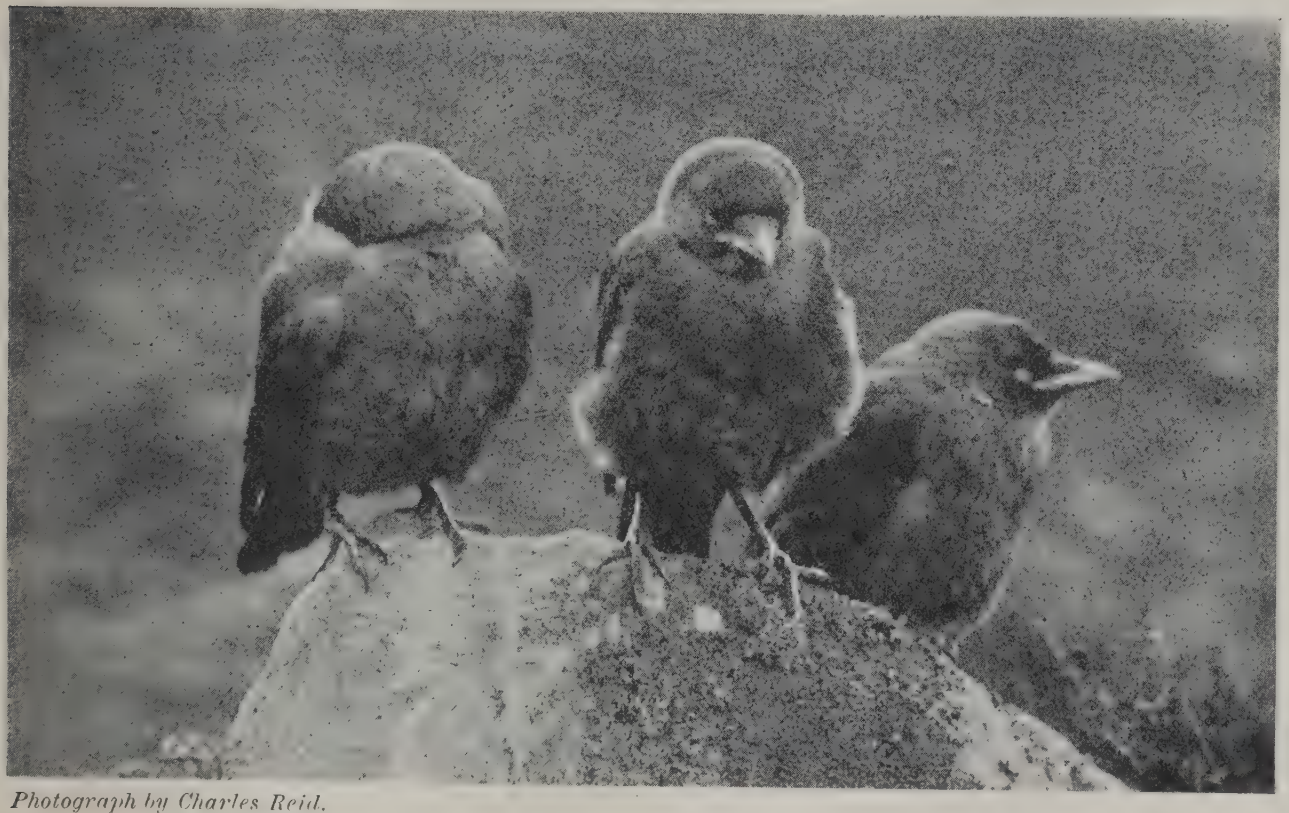
FIGURE 253.—A Robin's nest.

from Bedales School has shown a wild duck's nest under different aspects; the other, at Bootham, watched the hatching of gulls' eggs. (See Figures 248-252).

We are also enabled to reproduce one of a series of pictures of birds' nests made by a boy at Maidstone Grammar School. (Figure 253).

Few young photographers seem yet to have turned their attention to the taking of birds, which is a branch of the work which should certainly be followed up.

In taking up the photography of living things, the choice of a camera is an important matter, and according to our promise made in Part I, we have given in the Appendix to this volume* a



Photograph by Charles Reid.

FIGURE 254.—Young Jackdaws.

description of a piece of apparatus which has been specially designed by one of us, and which has been made by Messrs Watson & Sons.

We might point out what great possibilities exist of recording the actual movements of various creatures by means of the cinematograph, as has been so successfully done by Mr F. Martin Duncan, though we must at the same time mention that the expense and trouble incurred in carrying out this work would be very considerable.

* See Appendix, under the heading of Chapter XXIV.

Relics of Early Man

A branch of field work to which we have not previously alluded, is the hunting for and consideration of the relics of pre-historic man. The implements roughly chipped or carefully fashioned and polished which the primitive inhabitants of this country left behind them, form an interesting chapter in the Natural History of Man. Very many of the "flakes," scrapers and axes can be found on the surface of the ground during the course of rambles in the places where they occur. Other specimens may be dug out of river gravels, and others again discovered in caves, though it is not every day that opportunities for exploring new places of the latter kind present themselves.

CHAPTER XXXVII

THE USES OF MUSEUM COLLECTIONS IN NATURE-STUDY

WHILE it is quite obvious that the essence of nature-study is the consideration of living things and the actual work of Nature that is going on around them, yet there are cases in which preserved specimens have very important uses and in which they may supplement other material.

Collections, as they concern us, may first of all be looked upon as records and reminders of observations that have been made. In some respects actual objects may be of more value than drawings, though the effort of making the latter produces a greater impression upon the memory than even the most careful mounting of the things themselves. It is possible, however, by means of collections, to compare together, stages in the life history of plants and animals which are not met with at the same seasons of the year. To take a case. When the stages of the tadpole have been followed, and small frogs have appeared, it will be very advisable to review the whole story; and a series of well-preserved specimens, with their proper dates, will enable this to be done exceedingly well.

From collections some ideas may with advantage be obtained as to creatures which may be studied; and, below, we give an outline of the two sides of a school nature-study museum, and our suggestions as to exhibits illustrating our book are arranged in two columns according as they refer to lessons or out-door work.

In some cases where the specimens are always on view, it may be advisable to choose some other animal or plant than the one used in

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the lessons, so that the pupils may not know beforehand exactly what to expect, or because the particular subjects do not lend themselves well to exhibition.

Observational Lessons	Nature-Study

PLANTS

In connection with plants we may have series of specimens showing their growth from seed, and from some special part, such as a tuber. The potato may perhaps be replaced by something less bulky, and here a small collection illustrating the growth of a bulb may, if thought advisable, be introduced.

Sets of various seedlings may be added for comparison and to suggest the germination of others than those mentioned in the book. A series illustrating the economic importance of cuttings from stems, leaves, and roots, may very well be arranged, together with specimens showing the different methods that are adopted in grafting.

The next matter to be dealt with, is the ordinary life of plants and so much of their structure as it has been thought advisable to bring into the lessons. For instance, such objects as opening buds and falling leaves, on the one hand; and parts of a log, the skeletons of leaves and stems and peculiarities of plant construction, on the other.

There is hardly any end to the small collections that can be got together as time goes on, illustrating the various topics that we have touched upon, in connection with the growth and habits of plants. One series may represent methods adopted for climbing; another, such seeds as are distributed by the wind; or, again, plants that dwell together.

The plant may be further represented by specimens of flowers dried according to the methods suggested.

If necessary, insects which take a part in the fertilisation of flowers may be shown with them.

In addition, to those plants which do not flower that we have used as a basis for observations, others may be represented in such detail as is necessary.

It may be found possible to add one or two plants of this kind other than those which have been definitely alluded to. No doubt, however, in the consideration of local natural history, with which we deal later, illustrations of most forms will be included.

ANIMALS

On the animal side it may perhaps be possible to introduce life histories in addition to the specimens which here and there in the lessons are required for comparison. The skeleton of a man and a horse, or at least the skulls and limb bones, should be included; and if such things as a hedgehog, dove, and blindworm are shown, it should be with a view of giving opportunities for comparing such details as their outer coverings (suggested in Lesson XXX, page 114).

In this connection it will perhaps be unnecessary to go into much detail as to what specimens should be displayed. Life histories of insects other than those used in the lessons—small series to illustrate protective coloration and mimicry, or galls and their inhabitants—in fact, any on similar lines that will illustrate the many observations that may arise out of the various chapters which we have written to encourage outdoor work.

If possible, arrangements should be made for any living plants or animals that are under observation, to be kept with the other collections. In the school museum, also, a place should be found for good photographs of birds, and insects, and plants, taken by the pupils. Photographs obviate much unnecessary destruction of life, and they have the advantage over specimens that, whereas the latter might be grudgingly given to the school collection, or even kept by the finders, several copies may be easily made from the negative when once it is obtained.

It is hardly necessary to emphasize the fact that the pupils themselves ought to take part in the work of the school museum, otherwise the collection can never have the same value or interest for them, and much training of a particularly useful kind will be lost.

The efforts of the curator will of course be largely governed by the amount of space, of money, and more particularly of time, at his disposal. He should seek rather to show a few things arranged and labelled really well than a number kept in a slovenly way. It is difficult to gauge the bad effects of specimens that are not shown to advantage.

During the last few years we have had the opportunity of examining the results of much nature-study at the various exhibitions with which we have been connected; and it is surprising how much effect is lost, and how poor the outcome of really good work is made to appear, by the bad way in which the individual exhibits are very often displayed. Here and there throughout this book we have given such hints as we have been able to find room for; and we can only say further that specimens should not be crowded together, nor should they ever be exhibited without some definite purpose which is made clearer by means of their labels. Furthermore, it must be borne in mind that anything that is worth mounting should be "put

up" in such a way that it is preserved permanently, or for as long a time as possible, so that the labour expended upon it is not quickly lost.

The next purpose of a school museum to be considered is that of illustrating the local natural history ; first of all, with a view to showing what animals and plants or fossil remains of them may be found in the neighbourhood, and, secondly, in order to afford an easy means of recognising the creatures that from time to time will be discovered. Unless the museum is made a special feature of the school work, and plenty of room is available, it may not be possible to develop this last side of it to any great extent ; and what often happens is that one or two branches of natural history alone are pursued in which particular members of the staff or pupils are specially interested.

If there is, as there ought to be, a good local museum near at hand, it will obviate the necessity for extensive collections of the kind last mentioned.

We must not leave this subject without discussing a third side of the school museum which proves useful at a later stage when nature-study becomes combined with the consideration of the structure and relationship of the various creatures concerned, and grows into the pursuit of natural history in a wide sense. An endeavour should be made to indicate, by means of small carefully-chosen series of specimens and preparations, the main groups and classes of animals and plants, so that the position of any particular thing in the world of life can be at once found. The extent of such an "index collection" must depend upon circumstances, and although one may exist in the local museum, this should not prevent something of the kind from being arranged in the school even if there is no further accommodation for it than the walls of the class rooms.

In concluding this chapter let us urge those responsible for the display of school or private collections illustrating nature-study, to use good mounting material. Further, a rule should be made to give every individual specimen all the room it requires, so that it may be properly seen and to keep it to itself.

Objections will be raised on the score of expense and want of space, but let us see what is usually done; to start the school museum, a wall-case is procured, modelled more or less on the plan of book-shelves, with glazed doors containing small panes in front. The result is that several pounds at least are spent, the space for the display of specimens is at once limited, and much of it will be above the range of vision of young people. Small blame is there to them if they take but a small interest in the higgledy-piggledy collection that is often in consequence brought together.

Instead, series of boxes of uniform size, with glass lids, should be obtained, and for the reception of these, narrow shelves should be put up, well within the range of sight. The space between the shelves should be such that the boxes will easily fit into it, and if strips of wood are fixed so as to project above one shelf and below the next over it, the boxes may be held securely when slid in from either end. Sides fitted by means of dovetails which can easily be removed, will give a finish, and with an outlay of a few shillings a good start can be made.

APPENDIX (PART II)

A LIST OF MATERIALS AND APPARATUS REQUIRED, WITH DETAILS AS TO WHERE THEY MAY BE OBTAINED.

In this Appendix, under the headings first of the Lessons and then of the Chapters, an endeavour has been made to lighten the task of making preparations for the special nature-study work suggested. In the case of the Lessons, an approximate date has also been given.

Note.—Pumpkin seeds should be germinated in preparation for Lesson XIX, and bulbs of the lily (*Lilium lancifolium*) potted for use in Lesson XXIII. The latter work should be done some months before the plants are required.

Lesson XVII. (4th week in February.) *See* page 1.

Part I. *Dwarf Bean Seedlings growing in sawdust.*

Part II. *Apparatus for observing the Sun.* Made as described on pages 20 and 21, Part I.

Part III. *Potato Tubers, some of which are sprouting. Boxes with one glass side, filled with earth. Jars and strips of solder.* Very early potatoes should be chosen, such as Sutton's Ring-leader and Sutton's May-Queen, which can be obtained from Sutton & Sons, Reading. Price, roughly speaking, 5s. for 14 pounds.

Lesson XVIII. (1st week in March.) *See* page 9.

Part I. *Dwarf Bean Seedlings that have been grown in soil.*

Part II. *Frog's Spawn, glass dishes, pocket lenses.*

Alternative Subject. *Complete Crocus plants in flower.*

Part II. *New-laid Eggs.*

LESSON XIX. (2nd week in March.) *See* page 20.

Part I. *Dwarf Bean Seedlings in pots.*

Part II. *Potatoes growing in boxes and jars.*

Part III. *Frog's Spawn used during the previous lesson.*

Alternative Subject. *Pumpkin Seedlings sown a few weeks previously.*

Part IV. *Hen's Eggs that have been incubated for twenty-four hours.* These should have been placed under a broody hen, in a chicken incubator, or in a hot-water oven maintained at the proper temperature (39 degrees centigrade) by means of a regulator.

LESSON XX. (3rd week in March.) *See* page 28.

Part I. *The Tadpoles which have hatched from the Frog's Spawn.*

Part II. *Hen's Eggs that have been incubated for three days.*

Part III. *Horse-chestnut Twigs, bearing a terminal, and one or two lateral buds.*

LESSON XXI. (4th week in March.) *See* page 35.

Part I. *Potatoes growing in boxes and jars.*

Part II. *Horse-chestnut Buds kept in water from the previous week.*

Part III. *Lob-worms in dishes with damp moss.*

LESSON XXII. (1st week in April.) *See* page 42.

Part I. *Tadpoles kept from Lesson XX.* A set of preserved specimens illustrating the development of the tadpole.

Part II. *Horse-chestnut Buds which have been kept in water.* First used in Lesson XX.

Part III. *Common Wood-lice that can roll into a ball. The jars used for moulds, small rolls of damp rag.*

LESSON XXIII. (1st week in May.) *See* page 53.

Part I. *The Potato Tubers growing in boxes and jars.*

Part II. *Wood-lice similar to those used in the previous lesson.*

Part III. *Lily plants which are just coming into flower* (in pots).

Part IV. *Eggs of the silkworm.* To be obtained through the "*Exchange and Mart.*" Trays should be got ready and arrangements made for a supply of mulberry (or lettuce) leaves.

Lesson XXIV. (2nd week in May.) *See* page 62.

Part I. *The Lily plants.*

Part II. *Young Silkworms, in trays.*

Part III. *Living Worker and Drone Bees. The glasses used for mould culture. One or two queen bees. Hand lenses.*

Lesson XXV. (3rd week in May.) *See* page 72.

Part I. *Potatoes growing in boxes and jars.*

Part II. *The Lily plants.*

Part III. *Trays of Silkworms.*

Part IV. *Worker and Drone Bees, dead.*

Lesson XXVI. (4th week in May.) *See* page 78.

Part I. "*Supers*" *from a bar-frame hive, containing honeycomb in the course of construction.*

Part II. *Apparatus for observing the Sun.*

Part III. *The Lily plants.*

Lesson XXVII. (1st week in June.) *See* page 88.

Part I. *Potatoes growing in boxes and jars.*

Part II. *Common Snails, full grown. Tubular lamp chimneys.*

Lesson XXVIII. (2nd week in June.) *See* page 96.

Short branches of Hawthorn, False Acacia, Gorse: Wild Rose stem, and Holly leaves.

Lesson XXIX. (3rd week in June.) *See* page 107.

Part I. *Plants of Pea, Bryony, and Canary Creeper in pots. Thin wooden rods.*

Part II. *Apparatus for observing the Sun.*

Part III. *Goldfishes in glass vessels.*

LESSON XXX. (4th week in June.) *See* page 112.

Part I. *Sundew plants, growing in pots with sphagnum moss.* If specimens cannot be found wild (they occur in wet places on heaths), they may be obtained from the British Botanical Association, The Laboratory, Holgate, York. Price 6d. each in the summer.

Part II. *Living Ring-Doves in cages.*

LESSON XXXI. (1st week in July.) *See* page 117.

Part I. *Sundew plants.*

Part II. *Apparatus for observing the Sun.*

Part III. *Marble Galls, on oak twigs.* These can easily be found in country hedges.

Part IV. *Silkworms which have begun to spin in paper cones.*

LESSON XXXII. (2nd week in July.) *See* page 124.

Pieces of rough turf, six or more inches square.

Large pieces of paper. Wooden trays with raised edges.

LESSON XXXIII. (3rd week in July.) *See* page 132.

Part I. *Complete plants of the common Male Fern.*

Part II. *Silkworm Cocoons.*

CHAPTER XVIII.

A good compost for potting plants is made as follows:—Fibrous loam, six parts; a leaf mould, one part; well decayed cow manure one part: with a good sprinkling of sand. For cuttings, the sand should be increased in quantity. *See* page 7.

CHAPTER XIX.

The address of the Solway Fishery Company is Dumfries. The following are the descriptions and prices of small hatching tanks which will be sent carriage paid to any address in the British Islands, on the receipt of a

postal order for the amount indicated below. A hatching tank complete, in working order and a thousand eyed trout ova, price 11s. 6d.; a hatching tank and five hundred ova, 7s. 6d.; and a tank with one dozen ova, 2s. 6d. It would be preferable to ask, however, for the eggs to be sent in an earlier stage of development.

Eggs alone, can be obtained at the rate of 10s. for a thousand, a hundred for 2s. 6d., and a dozen for 1s. 6d. From the same fishery the eggs of other fishes, numbers of aquatic creatures and water plants can also be procured. *See* page 11.

Series of museum specimens illustrating the development of the fish can be obtained from E. J. Arnold & Son, Ltd., Butterley Street, Leeds, price 12s. 6d., with notes by Alfonso Gardiner, who edits the series. *See* pages 11-13.

Hints on the cultivation of protozoa.

Those who have at certain times to provide for class work or otherwise, large numbers of protozoa, often find it difficult or impossible to do so without recourse to a dealer. With care, however, it is possible to keep many kinds of protozoa so that a stock may be always at hand.

Amœbae should be kept in rain water (not from a water butt) or pond water provided it be not hard and so long as diatons are present. These may generally be got in stagnant, but not fetid water. The mud at the bottom, unless it be black (when the pond must be avoided) should be skimmed as thin as possible, and only the very topmost layer used. The head of a cod, if allowed to stand in cold water for some days, usually produces first a great number of infusoria, but later, millions of large colourless Amœbae admirably adapted for class work.

Paramœcium can always be induced to appear in myriads by collecting a few dead elm leaves, boiling them, and allowing the infusion to stand. Other leaves favour the growth of other infusoria. Paramoecium may be fed with bacteria (got by making an infusion of hay) or with oatmeal.

Epistylis will generally be found growing on the goose-weed (Elodea).

Dendrocometes, a remarkable acinetarian, is nearly always to be found on the gill, plates of the water shrimp—Gammarus.

Stentor, according to our experience, is generally to be found in pools on a stiff clay, rather than in sandy or chalky districts.

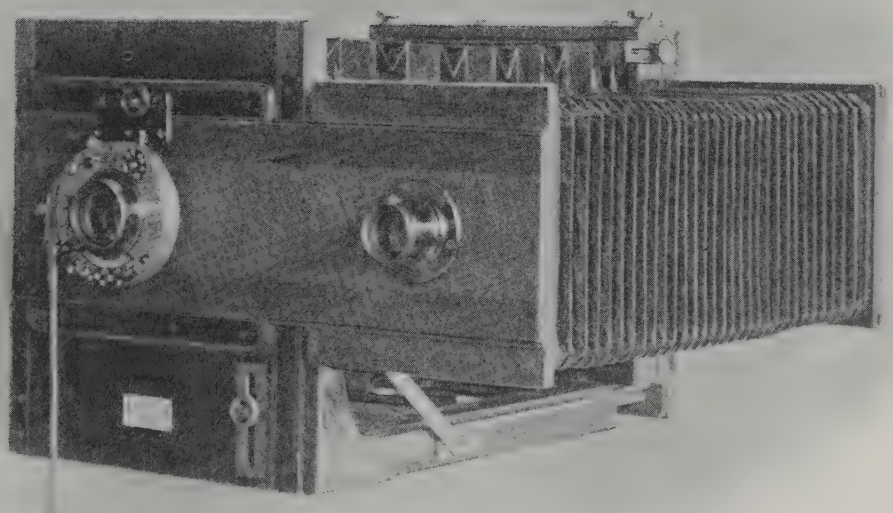
In all cases the secret of keeping these animals is to use small glasses, to avoid evaporation, and to *partly* change the water by means of a clean pipette every day. The temperature of the room where the aquaria are, should be as equable as possible.

The student will soon learn that the succession of protozoa in large aquaria, following as yet unknown laws, is one of the most puzzling facts about these animals. One day the tank will be swarming with, say, Actinosphaerium, and in two days they may have all disappeared. *See* page 15.

Chapter XXIV.

In taking nature photographs, the conditions are so various that the photographer will require apparatus to suit special cases. He can, of course, provide himself with a number of cameras, but the young nature student can hardly be expected to do this. An attempt has been made to design a camera which, while useful for all ordinary kinds of work, has yet special possibilities. In photographing live animals, particularly those which are small and have to be taken at close quarters, the nature photographer will at once feel the necessity of some means by which he can follow the slightest movement of the creature with his eye and with the focussing screw, while at the same time he has the power of exposing his plate on the instant. In the camera shown in the illustration, which is of half-plate size, this power is given by the attachment, when necessary, to its left side, of a light quarter-plate camera, of which the lens has exactly the same focus as that of the first. The idea is, that in an ordinary half-plate photograph of an animal the latter will seldom occupy more space in the centre than would be covered by a quarter-plate. In practice, the dark slide or magazine is placed in position at the back of the main camera and the slide drawn ready for exposure. The object is focussed upon the ground glass of the supple-

mentary camera, which is moved by the focussing screw of the other in such a way that the plate ready for exposure is maintained in register with it. The attachment of the supplementary camera to the sliding front and the swinging back of the other, permits of niceties of adjustment which could



Photograph by Messrs Watson & Sons.

FIGURE 255.—"The Eton Nature-Study Camera."

not be obtained if the cameras were arranged one above the other. As the picture in the supplementary camera is smaller than the one in its fellow, there is no necessity to make allowance for the fact that one lens does not absolutely cover the same field as the other. A cheap lens can of course be used in the supplementary camera, which latter can be removed at will when it is not required.

The nature photographer will find that when he wishes to take pictures of small insects as large or larger than life, that an ordinary camera will not extend sufficiently to give the required size. In the camera under consideration, the front focusses as well as the back, and so an extra extension up to 21 inches is obtained. It is often exceedingly useful to have a camera which focusses at the back, for instance when it is necessary to take a picture through a small hole or through the bars of a cage. Messrs W. Watson & Sons, of 313 High Holborn, have kindly undertaken to make this camera, which without lenses or shutter costs £15, including a tripod and three double slides. A holostigmatic lens is £7, 5s., and an "Everset" shutter £2, 15s. *See* page 50.

For photographing clouds process plates are recommended.

Ordnance Survey Maps are now supplied to schools for the *bona fide* use of scholars at a very cheap rate on application to the Director-General, Ordnance Survey, Southampton. Two hundred copies (no less number will be printed) of a map up to 18″ × 12″, from one sheet cost (a) for "outline," 25s.; (b) for "hill-shaded," 35s. *See* page 51.

Gum tragacanth mixed first of all with spirit, and then brought to the right consistency with water, is useful for attaching small things (which are to be kept in spirit) to sheets of glass. For large specimens, a mixture of glue and turpentine such as is used for sealing the lids of museum jars containing spirit should be adopted. It is made as follows:—

The best Scotch glue is broken up into small knobs and allowed to lie over night in a flat dish of water which should cover half its depth. In the morning it is placed in a tin and heated over water. *N.B.*—If the tin is placed in a saucepan, nails or something else should be placed in the latter, so as to allow water to run beneath the tin. When the process is completed, turpentine should be poured on to the surface in the proportion of about an ounce or an ounce and a half to every four ounces of glue originally taken. The material is used hot.

Boxwood topped bottles with wide mouths ("Pomades"), one ounce size, can be

obtained from Kilner Bros., Great Northern Goods Station, King's Cross. Price 11s. 6d. or 12s. 6d. a gross. *See* page 52.

CHAPTER XXV.

For glass topped boxes, see Appendix, page 149, Part I.

In the interim report of the Committee of the British Association on the preservation of plants for exhibition, Professor Errera calls the jars with hollow stoppers in which dried plants are kept, "Flacons à peptone Cornélis." He says they can be obtained from Vanderbought-Minne, rue du Berger, Brussels.

For pressing flowers, two boards held together by straps can be used, or better still, wire frames filled in with lattice work and galvanised, should be employed. These can be held together in the same way, and as Professor Trail points out in the report alluded to, they can easily be submitted to artificial heat. Another hint given by him is, that plants which require careful handling, or dissections should be placed between sheets of very thin paper and then put between ordinary drying papers which are changed as usual, the thin papers being left undisturbed. *See* page 60.

CHAPTER XXVI.

Syrup for feeding bees in the Autumn is made as follows :—

Boil 2 lbs. of loaf sugar (beet sugar should be avoided) in a pint of water for ten minutes. Add a table-spoonful of vinegar to prevent crystallisation, and half a tea-spoonful of napthol beta as an antiseptic.

In Spring, especially in warm weather, thinner syrup is best, $1\frac{1}{2}$ to 2 pints of water being used. *See* page 69.

E. J. Arnold & Sons, Leeds, sell preserved sets of specimens illustrating the life history of bees. Price 13s. 6d. *See* page 66.

CHAPTER XXVII.

Ants' nests can be obtained from E. J. Arnold & Sons, Leeds. Price 22s. 6d. *See* page 74.

CHAPTER XXIX.

Jewellers' wadding can be obtained from Potter & Sons, Aldersgate Street. Price per dozen sheets, 1s. 3d. *See* page 94.

CHAPTER XXX.

Since Part II was written, a book has appeared which gives some very good photographs of trees, taken at different seasons. It is by Edward Step, and is entitled "Wayside and Woodland Trees" (Warne & Company, 6s.). The volume is of a size convenient for the pocket and has rounded corners.

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